Ex-Post Project Evaluation 2016: Package I-1 (China)

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People's Republic of China

FY2016 Ex-Post Evaluation of Japanese ODA Loan Project

"Higher Education Project (Hebei Province)"

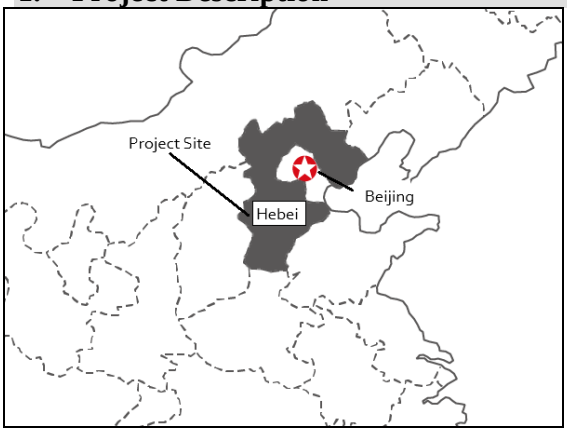
External Evaluator: Toshihiro Nishino, International Development Center of Japan Inc.

0. Summary

The project was implemented for the purpose of improving education and research at a total of 14 universities in Hebei Province in China through the improvement of relevant facilities and equipment and the training of teachers. Relevance of the project is evaluated to be high, as the project is consistent with (i) the higher education policies of China and Hebei Province, (ii) the development needs for quantitative and qualitative enhancement of the universities, and (iii) Japan's assistance policies. Although the effectiveness of the project is somewhat suppressed by the incompletion of the long-term specialist training, the quantitative as well as qualitative expansion of higher education at the targeted universities is achieved, including the fulfilment of tangible (hard) and intangible (soft) development needs and significant improvement of various educational indicators. The high level of effectiveness and the impacts of the project are also substantiated by the improved outcomes of educational and research activities, making the best use of the advanced equipment and training and by the advancements in the various initiatives designed to achieve regional vitalization, environmental conservation, etc. resulting from such use of equipment and training. Efficiency of the project is evaluated to be fair on the whole: although the project cost is as planned, the project period exceeds the planned period due to delays in procurement. Sustainability is evaluated to be high, with no issues being observed in institutional, technical and financial aspects, and the operation and maintenance of the facilities and equipment developed by the project are in good status.

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

1. Project Description



Project Locations

Civil engineering testing system installed under the project (Hebei University of Technology)

1.1 Background

In China, the further shift to a market economy due to the promotion of the reform and open door policy since 1978, newly achieved membership of the World Trade Organization, etc. and rise of environmental issues accompanying rapid economic growth made strengthening of educational and research activities pertaining to the field of market rules and environmental issues essential. Moreover, the emerging regional economic gap demanded quantitative and qualitative improvement of higher education through promotion of the local economy in less developed regions and an increased demand for higher education. In response the Government of China adopted such targets as a higher education enrollment rate of 15%, 16 million students in higher education and human resources development to serve the legal, financial, trade and other sectors in its 10th Five Year Plan.

The socioeconomic development of Hebei Province (area of 188,000 km^2; population of 67.69 million in 2004) lagged far behind other typical coastal provinces. Even though the 10th Five Year Plan for Education in Hebei Province (2001 – 2005) called for an increase of the higher education enrollment rate to 15% by 2005 along with a significant increase of the number of enrolled students, there was wide recognition of the need to deal with the tangible constraint (need to provide more school buildings and equipment), intangible constraint (need to train teachers) and financial constraint for the quantitative and qualitative expansion of higher education in Hebei Province.

1.2 Project Outline

The project aimed at quantitatively and qualitatively improving higher education by means of providing tangible assistance (improvement of buildings, equipment, etc.) and intangible assistance (implementation of training for teachers and administrative staff members and other assistance) for 14 targeted universities which would play an important role in the vitalization of communities, strengthening of market rules and environmental conservation in Hebei Province, thereby contributing to the fostering of human resources capable of contributing to the strengthening of market rules, environmental conservation and regional vitalization. [1] The targeted universities are listed below.

Hebei University, Hebei University of Technology, Yanshan University, Agricultural University of Hebei, Hebei Normal University, Hebei Medical University, Hebei University of Science & Technology, Hebei University of Economics and Business, North China University of Science and Technology, Hebei University of Engineering, Hebei North University, Hebei Normal University of Science & Technology, Chengde Medical University and Hebei Women's Vocational College (14 Universities)

Note: The university names are those at the time of the ex-post evaluation.

[1] This ex-post evaluation features the work conducted in Hebei Province as part of the Japanese ODA loan project entitled “Inland Higher Education Project” targeting 23 inland provinces, municipalities and autonomous regions in China.

Loan Approved Amount/Disbursed Amount	5,775 million yen/5,557 million yen	
Exchange of Notes Date/Loan Agreement Signing Date	June 2006/June 2006	
Terms and Conditions	Interest Rate Repayment Period (Grace Period Conditions for Procurement	1.5% 30 years 10 years) General untied
Borrower/Executing Agencies	The government of People's Republic of China / The People's Government of Hebei Province	
Project Completion	September 2013	
Main Contractor(s)	-	
Main Consultant	-	
Feasibility Studies, etc.	- "F/S by the Fourth Research and Design Engineering Corporation of China National Nuclear Corporation "(September, 2005) - "Special Assistance for Project Implementation (SAPI) for Higher Education Project in China", Japan International Cooperation Agency (JICA), 2003, 2004 and 2005. - "The Supervision Survey Report on JICA Loaned Higher Education Project", JICA, 2010.	
Related Projects	-	

2. Outline of the Evaluation Study

2.1 External Evaluator

Toshihiro Nishino, International Development Center of Japan Inc.

2.2 Duration of Evaluation Study

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

Duration of the Study: July 2016 - October 2017

Duration of the Field Study: October 30 - November 12, 2016 and March 12 - 18, 2017

3. Results of the Evaluation (Overall Rating: A[2])

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of China

The objective of the project was relevant to the national and provincial five year plans, the five year plan for the education sector and other education-related strategies of China at the time of both its appraisal and ex-post evaluation in the sense that the project "aimed at fostering highly capable human resources responding to social needs through the quantitative and qualitative improvement of higher education with a view

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

[3] ③: High, ②: Fair, ①: Low

to achieving socioeconomic development and solving the problem of a regional gap".

At the national level, there has been continuous emphasis to foster and expand core and key universities in the Midwestern part of China, and the relevant projects have been implemented.[4] While there have been no major policy changes since the time of project appraisal to the time of ex-post evaluation, the 13th Five Year Plan (2016 – 2020) gives high priority to supporting "a gradual increase of a number of world class universities and disciplines while creating world class universities and disciplines (promotion of construction of first class universities and disciplines".

Table 1: Main Objectives of Development Plans Related to the Project

Type of document	At the time of appraisal	At the time of ex-post evaluation
National level development plan	10th Five Year Plan (2001 – 2005) Increase of the higher education enrollment rate to around 15% by 2005	13th Five Year Plan (2016 – 2020) Improvement of the quality of the workforce and productivity through enhanced national education aiming at becoming a country with strong human resources; continued promotion of the modernization of universities (one numerical target for higher education is a gross enrollment rate of 90% or higher for senior secondary schools)
National level education sector plan	The 10th National Five year Plan for Education (2001–2005): To increase student enrollment in HEIs (higher education institutions) to 16,000,000 by 2005; to develop human resources that have high skills in high technology, biotechnologies, manufacturing technologies etc. that are necessary for industrial structural adjustment; to strengthen support to HEIs that are relatively at a high level in western area; to strengthen support to fostering of teachers.	The 13th National Five year Plan for Education (2016–2020) and National Mid- and Long-term Reform and Development Plan for Education Sector"(2010–2020): Promotion of the development of world class universities and disciplines; strengthening of the development of core and key universities in the Midwestern Region To increase higher education enrollment ratio from 26.5% in 2010 to 40% in 2020
Provincial level education development plan	10th Five Year Plan for Education in Hebei Province (2001 – 2005) (Target) • Higher education enrollment rate: 15% in 2005; 24% in 2010 • Number of university students: 900,000 in 2010	13th Five Year Plan for Education in Hebei Province (2016 – 2020) Promotion of the development of first class universities and disciplines; promotion of qualitative improvement and reform of education; enhancement of the general educational level; promotion of the reform of graduate school education (Target) Higher education enrollment rate: 42%

Source: Documents provided by JICA and plan documents

[4] Although Hebei Province does not normally belong to Midwestern China, it is included in the target area in such projects assisting higher education in the Midwest as the "Project for the Promotion of Higher Education in the Midwestern Part (2010 - 2020)".

3.1.2 Consistency with the Development Needs of China

Development needs were observed for the quantitative and qualitative enhancement of education at the 14 targeted universities during both the appraisal and ex-post evaluation.

At the appraisal stage, the future need for the quantitative expansion of higher education was predicted (i) in line with the further expansion of primary and secondary education and (ii) to narrow the economic disparity between Hebei and other coastal provinces as mentioned in 1.1 Background. The demand forecast suggested that the number of students enrolled at higher education institutions in Hebei Province would increase by approximately 1.6 times in eight years and the central government was urging the provincial government to strengthen both the tangible (expansion of buildings and equipment) and intangible (training of new teachers) aspects of higher education to respond to such increase of the educational need. The series of interviews for the ex-post evaluation found the common understanding among all of the targeted universities that "at the time of project appraisal, only limited financial assistance was available, failing the introduction or renewal of educational equipment in particular". As indicated by such understanding, there was a complete lack of funds to procure or renew such equipment at those principal universities controlled by the provincial government and targeted by the project.[5]

The results of the interviews with senior officials and those in charge of the project at the provincial education department and targeted universities at the time of the ex-post evaluation also suggest a continued need for further advancement of the "strengthening of market rules", maintenance of economic growth through "vitalization of the local economy" and elimination of gaps" (in terms of the GDP per capita, etc.)[6] with other coastal provinces. Meanwhile, "environmental conservation" has become a prioritized area for human resources development and also a target discipline for development because of the increasing need for the implementation of suitable measures against the background of the slow progress of raising environmental awareness and improving the state of air pollution in China. The number of students enrolled in higher education has steadily increased and there is a strong need for the quantitative and qualitative improvement of higher education institutions. There has been an increasing need for high quality human resources at the post-graduate level following ① the successful quantitative expansion of higher education in the 12th Five

[5] The financial sources for Chinese universities are subsidies by the central, provincial and other governments and own revenue from tuition fees, etc.

[6] The actual GDP per capita in 2016 was 42,866 yuan for Hebei Province with an average of 70,163 yuan for coastal provinces.

Year Plan period (2011 – 2015) and ② China's increased economic and industrial levels. As typically represented by the policy of "developing world class universities and disciplines", the emphasis has shifted from quantitative expansion to qualitative expansion but the overall aim is still the balanced expansion of quantity and quality. Moreover, the targeted universities of the project are core universities of which the development has been assisted by the provincial education department and some of them are subjects of projects for the promotion of higher education in the Midwest Part. As such, the project is relevant to the development needs of both the Government of China and the provincial government of Hebei.

3.1.3 Consistency with Japan's ODA Policy

At the time of appraisal, "Economic Cooperation Program for China" (2001), "Medium-Term Strategy for Overseas Economic Cooperation Operations" (JICA, April, 2002) and "Country Assistance Strategy" (JICA, 2002) all supported China's reform and open door policy, emphasized the development of human resources from the viewpoint of dealing with the necessary adjustment of economic structure after the entry in WTO and stressed Japan's assistance for China's inland area from the viewpoint of redressing disparity. As such, the project was relevant to Japan's ODA policy. The Country Assistance Strategy upholds "regional vitalization and exchange", "strengthening of market economy reform", and "environmental conservation" as key areas of human resource development.

Although Hebei Province is geographically a coastal province, it was selected as the target province for assistance because of ① the relatively backward education conditions of Hebei Province at the time of appraisal as in the case of other inland provinces, making the expansion of higher education an urgent task, and ② the GDP per capita of the province (13,017 yuan in 2004) being far below the average for coastal provinces (27,802 yuan). This decision was in line with Japan's ODA policy mentioned above.

The project is highly relevant to China's development plans, development needs at the time of both the appraisal and ex-post evaluation, as well as to Japan's ODA policy at the time of the appraisal. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The actual production of the outputs is summarized in "Comparison of the Original and Actual Scope of the project" of the final page of this report. In regard to the

tangible aspect of the project, the actual building area was smaller than planned because the laboratory building at Hebei University of Technology which was supposed to be constructed with a Japanese ODA loan was constructed with China's own funding to fulfil the "need to build it sooner than planned", diverting the funds earmarked for the ODA loan to the construction of an engineering training centre and civil engineering laboratory. It was assumed at the time of appraisal that the new buildings would be used by important organizations for the promotion of China-Japan exchanges. However, this original objective was not achieved because of the "change of the function of the buildings" at Hebei University of Technology and "failed materialization of the planned Japanese language department and China-Japan women's education research department" at Hebei Women's Vocational College. As the changes in terms of the purpose of the building and building area at Hebei University of Technology corresponded to the changed needs of the university, there were no major problems in relation to the output regarding the construction of the university building. However, because one reason for the selection of the building as the subject for a Japanese ODA loan at the time of appraisal was the eventual use of this building to promote friendly relations with Japan, such use of the building remains to be a pending issue.

In regard to educational equipment, a total of 27 procurement packages[7] were planned and these were duly completed except for some changes explained next. The bidding price for Package No. 1 (computers, etc.) exceeded the target price and rebidding was necessary. As urgently required equipment was procured with China's own funding, the contents of the equipment to be procured were adjusted for this rebidding. The low bidding price for Package No. 24 (Hebei University of Engineering; measuring instruments, etc.) led to the cancelling of the bidding. The successful bidder of the rebidding could not deliver some of the equipment at the bid price due to changes of the foreign exchange rate. As a result, equipment equivalent to some 30% of the contract price was cancelled. This cancelled equipment was eventually provided with the university's own funding. In short, the overall equipment procurement was almost as planned even though minor adjustments were made to the original contents of the planned equipment.

In short, it is safe to conclude that the hard outputs were generally achieved as planned.

[7] Of these 27 procurement packages, No. 1 through No. 9 were packages each of which featured specific equipment while each of No. 10 through No. 27 featured a specific university.

Table 2: Actual Buildings Constructed

University	Planned	Actual
Hebei University of Technology	Laboratory building: 25,000 m^2	Engineering training centre: 4,441 m^2 Civil engineering laboratory: 5,556 m^2 (total: 9,997 m^2)
Hebei Women's Vocational College	Lecture building (Foreign Language Institute), etc: 15,000 m^2	Lecture building (foreign language institute), etc: 15,000 m^2 (No change)
Total	40,000 ㎡	24,997 ㎡

Sources: Responses to the questionnaire from the executing agency.

Power plant operation simulation system installed under the project
(Hebei University of Engineering)

Lecture building constructed under the project
(Hebei Women's Vocational College)

Training at Japanese universities was conducted under the project as intangible support for the purpose of enhancing the level of expertise of teachers at the targeted universities (in principle, the targeted university or teacher hoping to receive training was supposed to select the host university or tutor and each trainee was accepted on an individual basis).

Table 3: Actual Training Outputs

	Planned (persons)	Actual output			Actual-Planned ratio	
		Total	Long-term specialist training	Short-term manager training	Total	Long-term specialist training
Actual training outputs	206	181 (incl.37 females)	49 (incl.21 females)	132 (incl.16 females)	88%	24%

Sources: Responses to the questionnaire from the executing agency.
Note: "Long-term specialist training" is to dispatch teachers with specific expertise are individually to host universities in Japan for a long period of time (long-term training of more than one year in a specialist field), while "short-term manager training" usually lasts for less than one month.

The total number of trainees was 181 or 88% of the planned figure (206). When the scope of analysis is limited to the type of training planned at the time of appraisal, i.e.

"dispatch of teachers with a high level of expertise in their fields to Japanese universities on an individual and long-term basis", the actual number of trainees meeting this criterion was only 49 (24% of the planned number of trainees). Of those who actually underwent training, 132 trainees (73%) participated in a short-term manager training course. The manager training course should serve to complement long-term specialist training, and the outputs of soft component were not realized necessarily as planned. There is a wide variety of factors for the failure of the long-term training to achieve its target at many universities as described in the box below. The biggest factor was the introduction of "stricter rules for trips abroad" by the Government of China.[8]

Factors for Non-Achievement of the Training Target: Common Factors Applicable to All Targeted Universities

- The introduction of "stricter rules for trips abroad" made it very difficult to obtain the approval of public money-funded overseas training from the Provincial Foreign Affairs Office and there were many cases of the denial of approval. (This policy began around 2009 and intensified in late 2011. Approval became almost impossible to receive from 2012).
- As a result of giving priority to introduction of educational equipment by the Hebei Education Department at the time of the project's commencement, efforts to deal with the soft component (especially long-term specialist training) of the project were delayed. (In addition, as more emphasis was placed on group training than on long-term specialist training, the former was implemented prior to the latter based on the need for the institutional reform, etc. of universities in China.)

Factors for the Non-Achievement of the Training Target: Factors Applicable to Some Universities

- As teachers hoping to undergo trainings searched for suitable Japanese universities on the Internet or through an introduction by an acquaintance, there were cases of mismatching, especially for universities with little experience of exchange with foreign universities.
- Some of the targeted universities were in the midst of expansion and had no leeway to dispatch their teachers abroad for a long period of time.
- Training in Japan was less attractive because of "a noticeable preference for training in Europe or the United States", "existence of numerous options for study abroad or overseas training," amongst other reasons.

[8] Foreign trips approved prior to the introduction of the stricter rules could go ahead. As many trainees for a manager training course had submitted their applications relatively early on, they were often successful in obtaining approval despite some unsuccessful applications. The Chinese universities with a relatively high number of long-term specialist trainees achieved such a number because of either ① obtaining of approval relatively early or ② participating in training using a personal passport outside the scope of policy application (most universities do not approve the use of a personal passport because of possible complications in the case of a problem).

In the past, there have been cases where the matching of a Chinese university sending trainees and a Japanese university accepting trainees does not go smoothly in human resources development projects in other provinces. At the time of appraisal, it was assumed that having learned from the past, the selection of trainees from Chinese universities and host universities in Japan would be based on an existing relationship between universities and/or researchers (would-be trainees and tutors) to facilitate smooth and advantageous matching. The interview survey with the Chinese universities involved in the project, however, found that many of these universities had no previous relationship with the host university (even in those cases where past exchanges are said to have existed, the reality was often for a Chinese university to submit the names of the host university to which they hoped to dispatch their teachers using reference materials provided by JICA). There were also cases of planned matching not materializing as a professor (teacher) with a contact with a host university at the time of appraisal had subsequently left or retire from the university by the time of project implementation. Accordingly, the new measure introduced to ensure the proper matching of Chinese and Japanese universities hardly achieved its intended purpose.

3.2.2 Project Inputs

3.2.2.1 Project Cost

As the actual total cost, including the administration cost, has not been obtained, the comparison between the planned cost and actual cost here is based on the total of the “building construction cost”, “educational equipment cost” and “training cost”. The project cost (excluding the administration cost) of 8,146 million yen (100% of the planned cost) was as planned.

The reduction of the building area at the Hebei University of Technology reduced the local currency portion of the building construction cost. Moreover, the actual training cost was approximately 41% of the planned cost due to a decrease of the number of trainees and shortening of the training period. In contrast, the actual equipment cost slightly exceeded (approximately 3%) of the planned cost. The background for this increase was ① allocation of the surplus funds to Package No. 1 based on (i) saving in the early contracted packages (as a result of international competitive tender) and (ii) cancellation of some equipment packages through the proper procedure (resulting in an increased actual cost of Package No. 1) and ② purchase of educational equipment with the own funding of the Chinese side, as they had been cancelled at the original bidding due to a higher bidding price than the planned price. It is difficult to simply compare the actual cost with the planned cost because of changes in terms of the contents of the construction work, contents of procured equipment and training period.

Nevertheless, the project cost (and the Japanese ODA loan amount) appears to have been adequately adjusted in a manner to reflect the changes of project contents and scale.

Table 4: Comparison between the Planned Cost and Actual Cost

Unit: million yen

	Plan (appraisal)			Actual		
	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total
1. Building Construction	342	413	755	349	367	716
2. Educational Equipment	4,962	2,160	7,122	5,088	2,222	7,310
3. Training	292	0	292	119	0	119
Total	5,596	2,573	8,169	5,557	2,589	8,146

Sources: Documents provided by JICA, responses to the questionnaire from the executing agency.
Notes
1) Planned exchange rate: 1 yuan = 13.7 yen (September, 2005)
   Actual exchange rate: 1 yuan = 14.1 yen (mean exchange rate between 2006 and 2013)
2) Planned total cost, including contingencies, administration cost, etc. at the time of appraisal: 9,116 million yen (foreign currency portion: 6,377 million yen and local currency portion: 2,739 million yen)

3.2.2.2 Project Period

The actual project period was 90 months, exceeding the planned project period of 60 months (150% of the planned period).

Table 5: Planned and Actual Project Periods

	Plan (appraisal)	Actual
Signing of Loan Agreement	June 2006	June 2006
Project period	April 2006 – March 2011 (60 months)	April 2006 – September 2013 (90 months)
Building construction	April 2006 – June2009	April 2006 – December 2008
Procurement of educational equipment	July 2006 – June 2008	August 2007 – September 2013
Training	October 2006 – March 2011	October 2007 – August 2013

Sources: Documents provided by JICA, responses to the questionnaire from the executing agency.
Note: As part of the project start using Chinese funding before the signing of the loan agreement, the commencement of the project was before this signing.

The biggest factor causing the excess project period was the delayed procurement of educational equipment. Of the 27 packages, Packages No. 1 and No. 24 required rebidding as described earlier, resulting in contract signing in 2011, in turn delaying the completion of the equipment inspection to 2013. Despite this setback, the respective contracts for 23 packages (accounting for 94% of the total contract price) out of 27 packages had been completed by the end of 2007. Therefore, the inspection of most of the equipment was completed within the initial project period (up to June,

2009).

For the purpose of achieving the smooth procurement of educational equipment, "equipment likely to be procured by all universities (computers, etc.)" were procured under the common packages (9 in total) hoping to enjoy a price curb effect of the economy of scale and the rest of equipment were procured through university-specific packages (18 in total) based on the recommendations and lessons learned from past similar projects in China. Although the actual procurement period for the educational equipment under the project exceeded the planned period, the situation was nowhere near the situation observed in other provinces where "the signing of the contract for many packages was considerably delayed" or "much of the planned equipment had not been procured at the end of the original procurement period". Most of the planned equipment under the project was introduced as planned and educational and research activities using such equipment were generally implemented as planned. Accordingly, this response (adoption of flexible packages) is believed to have significantly contributed to the achievement of the procurement of educational equipment in line with the planned period, assisted by appropriate project management by the Education Department of Hebei.

3.2.3 Results of Calculations for Internal Rates of Return

Due to the nature of the project, a quantitative analysis of the internal rate of return was not conducted.

Although the project cost was as planned, the project period exceeded the plan. Therefore, the efficiency of the project is fair.

3.3 Effectiveness[9] (Rating: ③)

The effectiveness of the project was analyzed from two aspects: the quantitative aspect, including the performance of operation and effect indicators and the qualitative aspect regarding the qualitative improvement of education and research as determined at the appraisal stage.

3.3.1 Quantitative Effects (Operation and Effect Indicators)

(1) Quantitative improvement of teaching and research

At the appraisal stage, "the number of students", "the total building area and "the total monetary value of the educational and research equipment" of the targeted universities were set as quantitative indicators for the improvement of education and

[9] Sub-rating for Effectiveness was given with consideration of Impact.

research. As shown in the following tables, Hebei province demonstrated substantial improvements for each indicator. The facilities and equipment developed under the project have been mostly utilized till the present, and it can be said that they have played theirrole as an integral part of the quantitative expansion of teaching and research.

Firstly, there was a substantial increase in the number of students at each of the targeted universities. The actual total number of enrolled students in 2014, one year after the completion of the project, was 348,000 (94% of the target). Even though this figure was 23,000 below the target figure (371,000), it showed a substantial increase by 94,000 (37%) compared to the baseline (2004). Such a large increase was recorded by most universities.

Table 6: Number of Enrolled Students (Total of Research Students, Full-Time Students and Special Course Students) and Building Area (Lecture Room, Laboratories, Library, Gymnasium and Lecture Hall) (Total of the Targeted Universities)

	Baseline	Target	Actual		
	2004	2012	2012	2014	2016
	Baseline Year	One Year after Project Completion	Original Target Year for Project Completion	One Year after Project Completion	Three Years after Project Completion at the Time of Ex-Post Evaluation
No. of Enrolled Students ('000)	254	371	359	348	358
Building Area ('000 m^2)	2,557	4,409 (40)	5,014 (25)	5,265 (25)	6,203 (25)

Sources: Documents provided by JICA, responses to the questionnaire from the executing agency
Notes
1) Research students, full-time students and special course students are equivalent to graduate students, undergraduate students and junior college students in Japan respectively.
2) The figure in brackets refers to the building area related to the project.

The building area also considerably increased at each university as in the case of the number of enrolled students. The actual figure for the original target year for completion (2012) set at the time of appraisal of 5,014,000 m^2 (total of all universities) already exceeded the target figure (4,409,000 m^2) (114% of the target value). From the year of 2004, the building area almost doubled in approximately eight years (increase by 2,457,000 m^2). The building area showed a continually increasing trend in subsequent years, reaching 5,265,000 m^2 in 2014, one year after project completion, and further to 6,203,000 m^2 in 2016, three years after project completion.

Meanwhile, the total monetary value of educational equipment at the targeted universities also recorded a substantial increase. Even though no target figure for the total monetary value of educational equipment was set at the time of appraisal, the actual value in 2012, i.e. the original target year for completion at the time of appraisal,

was 3,730 million yuan, recording an increase of 2.7 times in approximately eight years from 2004. The rate of equipment value increase exceeded the increase rate for the student number and building area. Both the questionnaire survey and interview survey with each university found that the operating rates of the buildings and equipment provided under the project were both high, indicating their effective use.

Table 7: Total Monetary Value of Educational Equipment
(Total of the Targeted Universities)

Unit: million yuan

	Baseline	Target	Actual				
	2004	2012	2012		2014		2016
	Baseline Year	One Year after Project Completion	Original Target Year for Project Completion		One Year after Project Completion		Three Years after Project Completion at the Time of Ex-Post Evaluation
	For All Universities	Under the Project	For All Universities	Under the Project	For All Universities	Under the Project	For All Universities
Total monetary value of educational equipment	1,390	500	3,730	480	4,950	500	6,200

Sources: Documents provided by JICA, responses to the questionnaire from the executing agency

(2) Qualitative improvement of teaching and research

At the time of appraisal, two indicators were introduced to indicate "qualitative improvement of education and research". These were "building area per student" and "monetary value of equipment per student" and their actual performance is shown in Table 8. There was a substantial improvement in this aspect as the size of increases in terms of the building area and equipment value exceeded the increase of the student number as mentioned earlier. The building area per student and equipment value per student (simple average for all of the targeted universities) had already exceeded the respective targets considerably in 2012, the initial target year for project completion (building area per student: 17.4 m^2 compared to the target value of 10.2 m^2; equipment value per student: 10,580 yuan compared to the target value of 5,847 yuan). Further improvement was made by 2014, one year after project completion.

Table 8: School Building Area per Student and Monetary Value of Educational Equipment per Student

	Baseline	Target	Actual		
	2004	2012	2012	2014	2016
	Baseline Year	One Year after Project Completion	Original Target Year for Project Completion	One Year after Project Completion	Three Years after Project Completion at the Time of Ex-Post Evaluation
School building area per student (m^2)	10.2	10.6	17.4	21.4	19.7
Value of educational equipment per student (yuan)	5,492	7,241	10,580	14,983	18,458

Sources: Documents provided by JICA, responses to the questionnaire from the executing agency.
Notes
1) Simple average of the corresponding values for the targeted universities
2) The national standard (for ordinary university departments) varies from one department to another. For example, the standard school building area per student ranges from 9 m^2 for a medical department to 22 m^2 for a social science department while the standard monetary value of equipment per student ranges from 3,000 yuan for a social science department to 5,000 yuan for such science departments as engineering, agro-science and medicine.

Table 9 summarizes the key indicators showing the effects of the quantitative and qualitative expansion of higher education (outcome indicators) among the various indicators for teaching and research activities. While each indicator showed some degree of improvement, noticeable improvement was recorded for a number of doctoral degree programs, number of key laboratories (at both the state level and provincial/ministerial level)[10], number of research projects (state level) and number of key disciplines (state level). For those indicators for which the target values were set at the time of appraisal, two (number of key disciplines at the provincial/ministerial level and number of master's degree programs) out of four indicators achieved their targets already in 2012, the original year for project completion at the time of appraisal. The target number of doctoral degree programs was achieved in 2014, one year after project completion. The results of interviews with senior officials and those in charge of the project at the targeted universities indicate that the project, in particular the consolidation of educational equipment, significantly contributed to the gaining of the certified status of key disciplines and key laboratories at many universities.

Since the commencement of the project, one college have been upgraded to universities, one university have commenced master's degree programs and two universities have installed doctorate programs.

[10] Those designated by a provincial government or ministry, such as the Ministry of Education, are classified as "provincial/ministerial level" while those designated by the state are classified as "state level".

Table 9: Trend of Major Teaching/Research Indicators (Total for the Targeted Universities)

	Baseline	Target	Actual		
	2004	2012	2012	2014	2016
	Baseline Year	One Year after Project Completion	Original Target Year for Project Completion	One Year after Project Completion	Three Years after Project Completion at the Time of Ex-Post Evaluation
Number of key disciplines (state level)	4	24	12	13	13
Number of key disciplines (provincial/ministerial)	77	138	147	177	184
Number of key laboratories (state level)	0	-	4	10	10
Number of key laboratories (provincial/ministerial)	18	-	114	139	164
Number of undergraduate faculties/departments	480	-	702	733	756
Number of master's degree programs	354	750	891	937	1,000
Number of doctorate degree programs	64	220	199	221	222
Number of research projects (state level)	130	-	444	481	642
Number of research projects (provincial/ministerial)	682	-	1,820	1,477	1,806

Sources: Documents provided by JICA, responses to the questionnaire from the executing agency
Note: Those indicators for which the target was not set at the time of appraisal were also included in the indicators to be evaluated.

3.3.2 Qualitative Effects (Other Effects)

(1) Effects of the hard components

Five positive effects of the hard component (tangible component) of the project were confirmed: ① contribution to being listed among world class universities and disciplines, ② contribution to improved assessment results of the targeted universities by the Ministry of Education, ③ improvement of teaching and research conditions and environment, ④recruitment of excellent human resources and ⑤ improvement of business scope and social services. These effects are detailed in table 10.

Table 10: Effects of Hard (Tangible) Component

Effect	Description
Contribution to being listed among World Class Universities and Disciplines	• A world class policy has been adopted in China with the aim of building world class universities and disciplines. In Hebei Province, of the 12 key universities aiming at becoming a world class university, 10 universities (four out of four universities earmarked for the first class and six out of eight universities earmarked for the second class) are targeted by the project. Of the 17 disciplines listed as world class disciplines, seven are priority disciplines for assistance under the project (Chemistry at Hebei University; Biology at Hebei Normal University; Material Chemistry/ Engineering at Hebei University of Technology; Mechanical Engineering and Material Chemistry/Engineering at Yanshan University; Metallurgical Engineering at North China University of Science and Technology; Crop Science at Agricultural University of Hebei). For a university or discipline to be listed as world class, it is essential to have an excellent reputation in terms of both tangible and intangible aspects and the consolidation of the tangible (hard) aspect under the project has greatly contributed to obtaining recognition as world class.
Contribution of Improved Assessment Results of Universities by Ministry of Education	• Universities in China are subject to periodic assessment by the Ministry of Education. The level of facilities and educational equipment is an important indicator in this assessment. There are many cases where the consolidation of hardware under the project has contributed to a university passing this assessment or obtaining an excellent assessment score (Hebei Normal University of Science and Technology (passed the assessment of its teaching standard in 2006); North China University of Science and Technology (same as above, 2006); Hebei University (same as above; 2007); Chengde Medical University (same as above; 2007)).
Improvement of Teaching and Research Conditions and Environment	• Key equipment as well as expensive equipment required for basic research was installed under the project, establishing a platform for teaching and research at the targeted universities (Hebei Medical University; Hebei University of Economics and Business; Agricultural University of Hebei; North China University of Science and Technology; Chengde Medical University; Hebei Normal University). At the time of introducing equipment, there were cases where the value of the equipment provided under the project exceeded 50% of the total value of equipment at the department or laboratory and analysis centre (section which centrally installs and controls important equipment at the university level). • The installation of state-of-the-art equipment which was absent before the project has enabled new research work and experiments (genetic recombination, etc.) The introduction of basic as well as core equipment under the project has enabled wide ranging research work together with the installation of application systems with the own funding of the university. • The project has improved the understanding of lessons, etc. on the part of students and the educational effect on the students due to ① the implementation of more integrated and practical teaching and ② increase of (i) number of equipment and (ii) opportunities for training and practical exercises per student.
Recruitment of Excellent Human Resources	• By introducing essential equipment for research in the specialist fields of the targeted teachers for recruitment (those who have studied in Japan), such teachers were successfully recruited. As a result, the research level of the universities concerned has improved in terms of better human resources and equipment.
Improvement of Business Scope and Social Services	• With the active use of the equipment introduced under the project, it has become possible to establish new disciplines and research departments (Hebei University of Economics and Business; Hebei University of Engineering; Yanshan University) • Following the designation as a model college for vocational training for women, new curricula have been introduced for women in rural areas as well as working women. Moreover, mobile classes are arranged to educate women in rural areas (Hebei Women's Vocational College).

Sources: Responses to the questionnaire from the executing agency

(2) Effects of the soft component

The findings of the interview survey with senior staff members and those in charge of project implementation at the targeted universities and the beneficiaries survey with the training participants indicated that many of the participants, excluding some universities, found the training that was part of the soft component of the project to be a useful opportunity to learn about the contents of advanced research and education, as it was rare to have the opportunity for long-term overseas training to obtain advanced specialist knowledge.

There were five positive effects of the soft component: ① fostering of the key persons of a university, ② upgrading of the research level and development of research in advanced or new fields hitherto unexplored, ③ strengthening of disciplines and research departments, ④ efforts to tackle social issues and ⑤ improvement of university management. These effects are detailed in Table 11.

Table 11: Effects of Soft Component

Effect	Description
Fostering of key university persons	• Many of the training participants are considered to be key persons at their own universities. • Many of them were promoted on their return to China and currently hold important positions, such as professors responsible for key laboratories at a university or department. Moreover, most training participants have written academic papers of various contents since their return to China, utilizing their training outcomes.
Boosting of the research level and development of research in advanced or new fields previously unexplored	• There are many cases where the research level has been enhanced (increase in the production of high-quality academic papers, among other aspects) and research in new fields, etc. has been initiated due to contact with the most advanced research fields and equipment in Japan. As a result, some cases led to upgrading to a state research project or participation in a project organized by an international research body. • According to the beneficiaries survey[11] with the participants of long-term specialist training, the top effects of the training are "upgrading of the research level" (74%), "improvement of the contents of education" (56%), "introduction of new research methods" (40%) and "commencement of research on new themes" (28%).
Strengthening of Disciplines and Research Departments	• There are many cases where training outcomes are used to effectively proceed with such new efforts as the establishment of new disciplines and research departments and strengthening of key disciplines. In several cases, various reference materials obtained in Japan prove to be useful. The improvement of both the hard (tangible) and soft (intangible) aspects under the project has definitely strengthened the disciplines and departments of the targeted universities.
Efforts to Tackle Social Issues	• There are cases where efforts are made with the cooperation of a local government to tackle such social issues as ① traffic congestion and ② problem of drug and stimulant abuse by utilizing the knowledge and know-how obtained in Japan concerning ① traffic simulation model and ② big data analysis.
Improvements in University Management	• According to the interview survey with senior staff members and those in charge of project implementation at the targeted universities and participants in manager training, appreciative opinions were heard that the short-term training course on university management was in line with the "need for promotion of the modernization and improvement of the management level". There are many cases of the positive use of the training outcomes although the level of such use varies from one university to another.

Sources: Responses to the questionnaire from the executing agency

3.4 Impact

3.4.1 Intended Impacts

(1) Enhancement of teaching and research results at the targeted universities

Table 12 outlines the performance of indicators that are believed to represent

[11] The beneficiary survey conducted as part of the ex-post evaluation is outlined here. (Target) Participants in training in Japan; (Method) Request to each university via the Provincial Education Department to make former trainees reply to the questionnaire (the selection of subject former trainees to reply to the questionnaire was left to each province and university because of the difficulty of conducting random sampling using a list); (Number of questionnaires sent) 100; (Number of valid responses) 100 (by course, 57 for the specialist course and 43 for the manager course) (by gender, 23 females and 77 males).

enhancement in teaching and research results (impact indicators) among the teaching and research-related indicators.

While improvement was made for each indicator, the actual number of academic papers and actual number of patented research outcomes in 2014, one year after project completion, were double or more than the respective reference figures in 2004, recording very high growth. Most of the universities recorded an improved graduation rate, graduate employment rate and post-graduate enrollment rate.

Such a general improvement of the impact indicators suggests that the quantitative and qualitative improvement of the teaching and research at the targeted universities has led to an overall improvement of the teaching and research results.

Table 12: Trends in Major Teaching/Research Impact Indicators

(Total of the Targeted Universities)

	Baseline	Target	Actual		
	2004	2012	2012	2014	2016
	Baseline Year	One Year after Project Completion	Original Target Year for Project Completion	One Year after Project Completion	Three Years after Project Completion at the Time of Ex-Post Evaluation
Number of award-winning research (state level)	3	-	2	3	0
Number of award-winning research (provincial/ministerial level)	142	-	288	280	268
Number of patented research outcomes	61	-	347	734	757
Number of research papers (SSCI)	0	-	30	39	32
Number of research papers (SCI/EI/ISTP)	1,206	-	4,812	5,175	3,944
Graduation rate	98.8%	98.9%	98.6%	98.7%	98.1%
Graduate employment rate	85.4%	-	91.0%	90.5%	91.0%
Post-graduate enrollment rate	18.2%	-	19.9%	20.2%	19.8%

Sources: JICA documents, responses to the questionnaire from the executing agency

Notes

1) Those indicators for which the target was not set at the time of appraisal were also included in the indicators to be evaluated.

2) SSCI stands for Social Science Citation Index, SCI for Science Citation Index, EI for Engineering Index and ISTP for Index to Scientific & Technical Proceedings.

Box: Outcomes at Targeted Disciplines for Assistance by the Project (Contribution of the Project)

In the past Higher Education projects implemented in other provinces, improvement of universities by China's domestic funding took place after the introduction of educational equipment and building construction with a Japanese ODA loan. As such, it was relatively easy to determine the level of contribution through Japanese ODA loan project. In Hebei province, however, improvement of the universities under the project progressed along with improvement with domestic funding and the level of contribution by the project was not very clear. For this reason, efforts were made by this ex-post evaluation to determine the level of contribution by the project by means of comparing the level of achievement of those disciplines receiving prioritized assistance under the project with the general level of achievement of the targeted universities. Some 42% of the educational equipment procured under the project was provided for key disciplines.

The state of improvement between 2004 and 2014 or 2016 by outcome indicator shows that a strong increase is observed especially of the monetary value of equipment per student for those disciplines receiving prioritized assistance of the targeted universities in general, presumably because of the reflection of the active investment in equipment under the project. However, the other indicators do not show much difference. With some indicators, the rate of increase for key disciplines is lower than that for the targeted universities in general. A similar tendency is observed with the impact indicators and the level of impact varies from one discipline to another. The likely reasons for these results are ① in 2004, the level of each indicator for the key disciplines was already higher than that for other disciplines, ② the introduction of versatile basic equipment which could be used by wide-ranging disciplines and departments at many universities widely benefited disciplines beyond the targeted disciplines, ③ following the improvement of the targeted disciplines under the project, efforts were made to improve other disciplines using domestic funds (to achieve the balanced improvement of all disciplines) and ④ the less than planned performance of the long-term specialist training as described earlier made it difficult for this training to produce the intended outcomes.

In view of the above, it is reasonable to conclude based on the performance of educational and research indicators that the project which was implemented along with improvement work using China's domestic funding contributed to an overall increase of educational equipment, etc. at the targeted universities, thereby contributing to the improvement of these universities (the improvement of each indicator is the combined result of funding under the project and the use of domestic funds).

(2) Enhancement of teaching and research at the provincial level

The performance of the higher education indicators in Hebei province is shown in Table 13. The provincial level quantitative indicators generally exceeded their respective targets assumed at the time of appraisal except for some indicators, including the number of enrolled students and the graduation rate. As the universities targeted by the project are ranked high in scale among the regular higher education institutions (HEIs), they play a major role in the improvement of these higher education indicators at the provincial level.

Table 13: Higher Education Indicators of Hebei Province

	Baseline	Target	Actual	Actual		
	2004	2012	2012	2014	2015	2016
	Baseline Year	One Year after Project Completion	Original Target Year for Project Completion	One Year after Project Completion	Two Years after Project Completion	Three Years after Project Completion at the Time of Ex-Post Evaluation
Number of regular High Education Institutions (HEIs)	87	95	113	118	118	120
Number of students enrolled in regular HEIs (persons)	940,000	1,500,000	1,164,300	1,164,300	1,179,200	1,216,100
Enrollment rate in HEIs	18.9%	25%	23%	31%	43%	n.a.
School building area per student (m^2)	10.1	17.0	27.5	28.6	29.1	26.5
Monetary value of educational equipment per student (yuan)	3,984	5,847	7,924	9,425	10,328	10,094
Number of students per teacher (persons)	18.5	16.0	17.9	16.9	16.9	17.3
Graduation rate	99%	99%	99%	94%	95%	96%
Graduate employment rate	78%	92%	85%	95%	95%	96%
Post-graduate enrollment rate	11%	22%	9%	9%	9%	9%

Sources: JICA documents, responses to the questionnaire from the executing agency

(3) Contribution to regional vitalization, strengthening of market rules and environmental conservation

In regard to the impacts on three development themes identified at the time of appraisal, i.e. ① regional vitalization, ② strengthening of the market rules and ③ environmental conservation, it was difficult to obtain quantitative data indicating the general situation. These impacts were also difficult to segregate as large universities were the subject of many projects in addition to this Higher Education Project. Nonetheless, several cases of contribution have been identified, as described below.

1) Regional vitalization

Leading universities in the engineering, education, medical and social science fields were included in the targeted universities and they have constantly producing graduates in those fields which are essential for regional vitalization. At some of the targeted universities, research work contributing to the promotion of key industries (steel, mining, etc.) in Hebei Province is in progress using equipment installed under the project. These industries provide the main employment opportunities for graduates. As the number of graduates increases, the number of graduates employed in these industries also increases. The promotion of key industries and the vitalization of poor areas are leading policy issues of every provincial government. Each university is engaged in many projects commissioned by government organizations, notably provincial government, contributing to regional vitalization. Moreover, there are many cases where universities become involved in local development by cooperating with local companies and organizations.

Table 14: Examples of Achievements Related to Regional Vitalization

University	Examples of Achievements
North China University of Science and Technology	• Establishment of the Enterprise Support Team to accept entrusted research or joint research from local enterprises to assist their improvement of production • Employment of graduates of the Japanese Language Course by local Japanese subsidiaries, contributing to the local economy (attracting inward investment and expanding the activities of Japanese subsidiaries)
Hebei Normal University of Science and Technology	• Establishment of the Social Contribution Team to assist the promotion of agriculture, targeting poor villages in the eastern part of Hebei Province, using equipment introduced under the project for soil analysis, etc.

Sources: Responses to the questionnaire from the executing agency

2) Strengthening of market rules

All universities in China are moving to become comprehensive universities. As a result, the number of graduates in relevant fields (Faculty of Law, Faculty of Accounting and Business Management, etc.) has generally shown an increasing trend at the targeted universities which are characterized by their emphasis on producing graduates capable of immediately conducting the necessary work to strengthen the market rules. Much of the educational equipment provided under the project has been regularly used for the purpose of producing industry-ready graduates.

Table 15: Example of Achievement Related to Strengthening of Market Rules

University	Example of Achievement
All of the Targeted Universities	• Active engagement in the production of industry-ready graduates (① practical guidance for students through the introduction of a business management simulation system and software actually used by enterprises and ② active implementation of economic management-related lessons with science or engineering students)

Sources: Responses to the questionnaire from the executing agency

3) Environmental conservation

The environmental field has become a key discipline at many universities due to the increasing need in China, and conscious efforts have been made to bolster environment-related disciplines. There have been cases where new environmental courses and departments have been established, and environmental studies have been designated as a key discipline after the commencement of the project. A number of graduates from the environmental courses has been increasing and environmental conservation was one of the prioritized areas for the consolidation of educational equipment and training in Japan under the project. There are many cases of a university receiving a grant (from the National Science Foundation of China, etc.) for a research project or being entrusted with a project by the administration. Some of these cases use the equipment and systems provided under the project and/or former trainees.

Table 16: Example of Achievement Related to Contribution to Environmental Conservation

University	Example of Achievement
Yanshan University	• Invitation to a professor of Toyama University in Japan for exchange on solid waste treatment and waste water treatment (special lecture at the university and exchange of opinions after a field visit in China)

Sources: Responses to the questionnaire from the executing agency

(4) Facilitation of Cooperation and Mutual Understanding between Chinese and Japanese Universities

Table 17 summarizes the actual exchanges between the targeted universities and host universities in Japan after the completion of training (average number of exchanges per university). There are several cases of short mutual visits of professors or students. In contrast, the number of joint events, such as joint research and joint seminars, is rather small.

Table 17: Exchanges with Host Universities in the Post-training Period
(Aggregate from the End of Training to the Present: Average per University)

	Number of Inter-University Exchange Agreement	Short visit to Japan (times)	Short visit to China (times)	Acceptance of Japanese students (persons)	Dispatch of students to Japan (persons)	Joint research (projects)	Joint event (times)
Average of the Targeted Universities	0.8	6.2	6.8	2.8	7.8	0.3	0.4

Sources: Responses to the questionnaire from the executing agency

As described above, the actual performance of long-term specialist training was significantly lower than planned. As a result, many of the targeted universities conduct hardly any exchanges with Japanese universities, failing to achieve a sufficient outcome except for some universities. Those universities with ongoing exchanges used to have exchanges with Japanese universities prior to the project and these ties appear to have been enhanced by the project. Some concrete examples of achievements are shown in Table 18.

Table 18: Examples of Achievement Relating to the Promotion of Cooperation and Mutual Understanding between Chinese and Japanese Universities

University	Examples of Achievements
Hebei Medical University	• Since the completion of the project, new research exchanges with Japanese universities using the newly introduced equipment have been promoted and intensified. In the field of forensic medicine, equipment contributing to the promotion of joint research with Japanese universities was introduced under the project and 19 joint research projects were implemented between 2008 and 2016. • Training was conducted with the guidance of a professor of Tokyo University with whom a teacher of Hebei Medical University was acquainted at an academic conference and the joint research conducted after the return to China produced three academic papers. Through the project, it has become possible to conduct such state-of-the-art joint research as the recombination of animal genes. Subsequently, three members of the same laboratory were dispatched to Tokyo University, continuing the exchange at an institutional as well as personal level.
Hebei University	• The relationship with Tottori University which existed before the project was strengthened. Using the project as momentum, an academic exchange agreement was concluded between the two universities.
Yanshan University	• Hiroshima University was already a sister university before the project. Using the project as momentum, the relationship was further strengthened, including the implementation of a joint project to nurture Ph.D. students from 2012.
Agricultural University of Hebei	• Using the project as momentum, the university formulated the "Overseas Training Program for Young Teachers" for the purpose of sending many teachers overseas for training. Using its internal funds, the university allocated 5 million yuan a year to the program to send teachers to Europe, the USA and Japan. As a result, exchanges with Japanese universities have increased. The project has contributed to the shift of emphasis on overseas training/study to develop the university's human resources.
Hebei North University	• The relationship with Kyushu Foreign Language Academy has been strengthened along with the realization of an increased number of students sent to Japan for learning.

Sources: Responses to the questionnaire from the executing agency

3.4.2 Other Positive and Negative Impacts

(1) Impacts on the natural environment

No negative impacts on the natural environment were observed. The environmental impact assessment (EIA) for the project was completed by the time of the appraisal and was approved by the Environmental Protection Bureau, and relevant procedures in China were all completed. Each university has been conducting necessary environmental monitoring of noise, dust, etc. during and after the project. According to those responsible for environmental issues at each university, as all of the measured values have been within the relevant standards set by the government, no problems have been identified.

(2) Land acquisition and Resettlement

As all of the new buildings were constructed on the existing university campuses, no

resettlement of residents or acquisition of land was required.

This project has largely achieved its objectives. Therefore, the effectiveness and impact of the project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

As planned during the appraisal, the facilities and equipment prepared under the project are operated and maintained by each targeted university, and the Education Department of Hebei of the subject province—the executing agency—oversee them. All targeted universities added the developed facilities and equipment to the universities' fixed assets and established the operation and maintenance system with clearly defined responsibilities and procedures by creating regulations such as the procedures for maintenance of large equipment and fund management, work regulations on experiment teaching, the procedures for fixed asset management, etc. In universities with a large number of equipment, there is a unified management system in place for the purpose of enhancing the effective and efficient use of the equipment. One example is the installation and operation of important equipment, including that provided under the project, at the testing and analysis centre. The respective roles of stakeholder organizations are clearly defined and no problems are found in regard to the staff strength required for equipment operation and management.

3.5.2 Technical Aspects of Operation and Maintenance

No issues were observed in the technical aspects, since all targeted universities regularly carried out maintenance and inspection of the facilities and equipment and outsourced repair works to contractors, such as suppliers, when necessary. To secure the skills necessary to operate and maintain large laboratory equipment and sensitive measuring or analysis equipment, the universities appoint full-time technical staff for each instrument or laboratory to manage the equipment in an integrated manner. At all targeted universities, the manuals and precautions are posted near individual instruments for easy reference. Moreover, teachers in charge of operating and maintaining sensitive equipment receive regular technical training from the manufacturers. There are cases where mastering of the know-how to effectively use advanced equipment through training in Japan led to the improvement of operating skills. The utilization rate of the newly procured equipment has been high, and various research and educational activities using these equipment suggest that there are no issues regarding the technical capability of using the equipment.

3.5.3 Financial Aspects of Operation and Maintenance

The targeted universities are all affiliated with the provincial government. Their budgets consist of subsidies from the state or province and own income such as tuitions and fees. The interview survey with universities found that the financial support for universities by the government gradually increased under the 11th Five Year Plan (2006 - 2010), and this support was further consolidated under the 12th Five Year Plan (2011 - 2015). As shown in the table below, the increase of the provincial budget for education has been maintained even since 2011. Although the actual figure varies from one university to another, each university receives a minimum of several million yuan a year from the central government. In the case of large universities, the financial support amounts to 20 to 30 million yuan a year, including those by the provincial government, to maintain and improve the facilities. The available financial data indicates a steady expenditure level or trend of increase of both the provincial budget for education and university budgets and the balance between the income and expenditure is favorable in the targeted universities. Every university ensures sufficient budget allocation to cover the equipment maintenance cost. None of the principal equipment procured under the project has been unused due to an insufficient operating budget or repair budget.

Table 19: Financial Expenditure for Education of the Central Government and Hebei Province

Unit: million yuan

		2011	2012	2013	2014	2015
Central Government	Expenditure for education	99,905	110,146	110,665	125,362	135,817
	Educational expenditure index (2011 = 100)	100	110	111	125	136
Hebei Province	Expenditure for education	84,453	104,391	102,974	108,749	128,788
	Of which is the higher education expenditure	17,361	24,985	22,670	23,382	25,170
	Higher education expenditure index (2011 = 100)	100	144	131	135	145

Source: Statistics for Hebei Province and Responses to the questionnaire from the executing agency

3.5.4 Current Status of Operation and Maintenance

In all targeted universities, the equipment developed by this project are registered in the maintenance and management database. All expensive equipment are also registered and controlled by the public platform run by the provincial science and technology agency. Based on the observation and review of usage or inspection records for each equipment, it was confirmed that the principal equipment and systems were mostly in good condition. Some equipment, such as PCs, have short service lifespans.

While the deterioration of such equipment is now causing some problems, it is still continuously used. In the case of important equipment, there is a system at all the universities for users to record the equipment conditions and to note every time the equipment is used.

According to the replies of the targeted universities, expendables are stocked at a sufficient level as long as they are still produced and there are no problems in this aspect. (Those out of production are limited in number and can be sufficiently replaced by alternative products).

No major problems have been observed in the institutional, technical and financial aspects and current status of the operation and maintenance system. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project was implemented for the purpose of improving education and research at a total of 14 universities in Hebei Province in China through the improvement of relevant facilities and equipment and the training of teachers. Relevance of the project is evaluated to be high, as the project is consistent with (i) the higher education policies of China and Hebei Province, (ii) the development needs for quantitative and qualitative enhancement of the universities, and (iii) Japan's assistance policies. Although the effectiveness of the project is somewhat suppressed by the incompletion of the long-term specialist training, the quantitative as well as qualitative expansion of higher education at the targeted universities is achieved, including the fulfilment of tangible (hard) and intangible (soft) development needs and significant improvement of various educational indicators. The high level of effectiveness and the impacts of the project are also substantiated by the improved outcomes of educational and research activities, making the best use of the advanced equipment and training and by the advancements in the various initiatives designed to achieve regional vitalization, environmental conservation, etc. resulting from such use of equipment and training. Efficiency of the project is evaluated to be fair on the whole: although the project cost is as planned, the project period exceeds the planned period due to delays in procurement. Sustainability is evaluated to be high, with no issues being observed in institutional, technical and financial aspects, and the operation and maintenance of the facilities and equipment developed by the project are in good status.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

(1) Importance of Sufficient Gathering of Accurate Information at the Time of Planning of Training Components

In the project, information on past exchanges with Japanese universities, etc. was gathered in advance from the targeted universities, taking into consideration the lessons learned from the Higher Education projects in other provinces that matching with a host university in Japan had not been smoothly conducted. Based on this information, the candidate host universities in Japan (with which a targeted university had exchanges in the past or an exchange agreement) and candidate trainees (those who had an experience of exchange before) were narrowed down. However, according to the interview survey with those of the targeted universities, even if past exchanges with a candidate host university were said to have existed at the time of appraisal, no such exchanges existed with a targeted university, in reality. There was also a case where a professor with experience of an exchange did not participate in the training as he had moved to another university by the time of the commencement of the project. In short, the advance information gathering made hardly any contribution to the smooth matching.

When training in Japan is to be included in a similar education project as a project component and a recipient country's organization is supposed to search for the host university under the leadership of an organization of the recipient country, it is essential to thoroughly obtain accurate information on the relationship between the candidate host university and the university (organization) dispatching trainees at the project planning stage. In particular, when the gathering of information is entrusted to an organization of the recipient country, there may be a case where the gathered information may not be accurate. Therefore, sufficient care and verification efforts are required, including the checking of certificates and other documents. Failure to gather accurate information may lead to a delayed or incorrect response, possibly causing serious adverse impacts on the project outcomes. It is also vital to plan and implement the necessary measures to solve problems based on the information gathering results and to monitor the effects of these measures.

(2) Necessity for Measures for the Systematic Implementation of the Training Component in a Financial Cooperation Project

When a financial cooperation project involving a large-scale training component is planned (especially when the project targets multiple organizations), it is important for JICA and the executing agency to prepare a viable plan, including an implementation schedule, at the planning stage and to adopt proper measures at the implementation stage to ensure systematic and steady implementation based on the plan so that the impacts of external factors can be minimized and the planned outcomes fully achieved.

The project initially planned to train (mainly long-term specialist training) total 206 people from 14 universities in Hebei Province at various Japanese universities. The status of training in the project was presumably very high at the planning stage while no training schedule, etc. were prepared. The emphasis of the executing agency on the introduction of equipment meant the delayed handling of the training component. The subsequent introduction of a policy for "stricter rules for trips abroad" (commenced in 2009) by the Government of China produced many cases where the permission to train in Japan was not granted. Consequently, the number of trainees which actually participated in long-term specialist training was as low as 49 (23 up to 2009 when the said policy was introduced). As a result, post-training exchanges between Chinese and Japanese universities have been low key. The delay of the training component increases the potential for negative impacts caused by such external factors as various policies even if they are not directly related to the project. For the training component of the project, therefore, it must have been necessary to formulate a feasible implementation plan centering on the implementation schedule through consultations with the executing agency and also to manage the progress of implementation to ensure the steady realization of training without delay (these consultations on plan formulation can expect such positive effects on the executing agency as ① reconfirmation and sharing of the importance of the training component and implementation procedure and ② promotion of a soft component which promises a strong synergy effect with the hard component). It may also have been worthwhile to identify the possible risks to ensure the implementation of the training component as planned so that measures to avoid such risks could be examined and worked out in advance.

It is essential to prepare thorough measures, especially when the targets of a project are multiple organizations. In the case of this project, one reason for the lack of a prior arrangement of the training implementation schedule may have been the fact that the targeted universities and potential trainees were expected to search for their own host universities. However, prior consent for the implementation schedule to a certain extent would have contributed to the smoother implementation of training.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1.Project Outputs	Targets: 14 universities in Hebei Province	Target: Same as planned
(a)Hard Component i) Construction of Buildings etc.	Hebei University of Technology: - Laboratory Building: 25,000 m^2	Hebei University of Technology: - Engineering Training Centre: 4,441 m^2 - Civil Engineering Laboratory: 5,556 m^2
	Hebei Women's Vocational College - Foreign Language Institute Building: 15,000 m^2	Hebei Women's Vocational College: Same as planned
ii) Procurement of educational equipment	384 pieces 1) Basic educational equipment 2) Laboratory and research equipment 3) Development of educational infrastructure (communication network, etc.)	387 pieces Same as planned
(b)Soft Component Teachers' training in Japan	206 persons Biology, medicine, chemistry, physics and other	181 persons University management, environment, mechanical engineering and other
2.Project Period	April 2006 – March 2011 (60 months)	April 2006 – September 2013 (90 months)
3.Project Cost Amount Paid in Foreign Currency	5,775 million yen	5,557 million yen
Amount Paid in Local Currency	3,341 million yen (243.9 million yuan)	2,589 million yen (183.6 million yuan)
Total	9,116 million yen	8,146 million yen
Japanese ODA Loan Portion	5,775 million yen	5,557 million yen
Exchange Rate	1yuan =13.7 yen (As of September 2005)	1yuan =14.1 yen (Average of Project period 2006-2013)
4.Final Disbursement	October 2013	

People's Republic of China

FY2016 Ex-Post Evaluation of Japanese ODA Loan

"Yunnan Province Kunming City Water Environment Improvement Project"

" Yunnan Province Kunming City Water Environment Improvement Project（II）"

External Evaluator: Shima Hayase, IC Net Limited

0. Summary

The objective of this project is to improve the sewage treatment capacity in the city center of Kunming City in Yunnan Province by upgrading sewage treatment plants, thereby contributing to the improvement of the living environment in the area through the reduction of water pollutant in Dianchi Lake.

This project was consistent with China's development policies and development needs at the national, provincial, and municipal levels; in accordance with Japan's policy for assistance to China at the time of the appraisal. Therefore, its relevance is high. Expected effects have arisen because indicators for the main effects, such as the sewage treatment rate and the quality of the treated water, have achieved the targets. In 2016, for the first time in 30 years the water quality of Dianchi Lake which had been inferior class V[1], the lowest water quality standard, improved to class V. Reinforcing the sewage treatment capacity resulted in improvement of the quality of water discharged. The effectiveness and impact of this project are significantly high, because this project widely contributed to a decrease in the major pollutants discharged from the urban district of Kunming City into Dianchi Lake. The renovation of the sewage treatment plants, the expansion, the new establishment and construction of the pump stations and pipe network were conducted as scheduled and the project cost was lower than planned. A considerable delay was caused in the project period so that the efficiency of the project is fair. Regarding the sustainability of the effects that arose from this project, there are no problem in the operation and maintenance structure of the managing agency, the technological, and financial aspects. Therefore, the sustainability of the project is high.

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

[1] The water quality for rivers, lakes, and other water environments is classified into Class I-V pursuant to the Environmental Quality Standard for Surface Water (GB3838-2002). Class I: Applies primarily to water from water sources and national nature reserves; Class II: Applies primarily to concentrated water sources of potable water for domestic use in Class I preserves, valuable fish protection areas, and fish and shrimp spawning grounds; Class III: Applies primarily to concentrated water sources of potable water for domestic use in Class II preserves, general fish protection areas, and swimming areas; Class IV: Applies primarily to general industrial water areas and water areas for entertainment purposes that do not come into direct contact with humans; Class V: Applies primarily to agricultural water and water areas needed for general scenery. Below V is classified as inferior V.

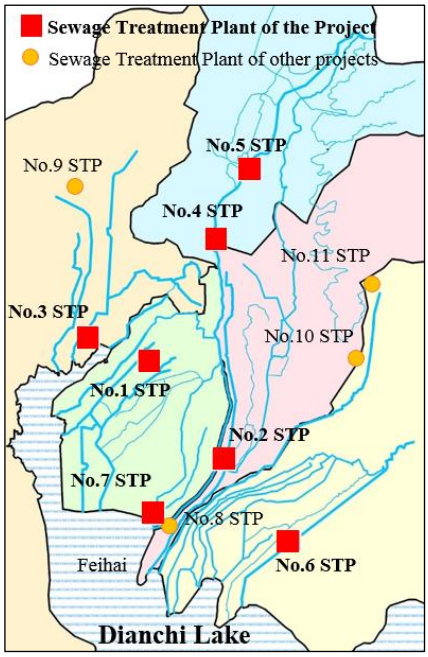
1. Project Description

Project location

Dianchi Lake Designated as a Natural Reserve

1.1 Background

Kunming City, the capital of Yunnan Province, has been one of the development hubs in Western China and an economic, transport, and trade center. Economic development of the city were accompanied by a rapid increase since the 1980s in the volume of untreated sewage flowing into Dianchi Lake, a fresh water lake on the Yangtze River. In the 1990s, the water quality of the lake worsened below the level unusable as agricultural water. Due to its geological formation with all the rivers in the city flowing into the lake, untreated sewage significantly affected the water quality of the lake. Thus, *the 10th Five Year Environmental Protection Plan (2001-2005)* regarded improvement in the water quality of the lake as a national key project and Kunming People's Government conducted the construction of sewage treatment plants and improving a network of sewage pipes in the city center. However, while the volume of discharged sewage was 688,000 m^3/day, sewage treatment capacity was only 464,000 m^3/day. As a result of that, untreated sewage continued to flow into Dianchi Lake. Moreover, due to an increase in population and so on, it was foreseen that the volume of discharged sewage would increase to 900,000 m^3/day in 2015. Thus, the improvement of sewage treatment capacity in the city and limitation of water pollutant substances flowing into the lake were urgent issues.



Source: Drawn from the material provided by Executing Agency

Figure 1: Dianchi Lake and sewage treatment plants in the city

1.2 Project Outline

The objective of this project is to improve the sewage treatment capacity in the city center of Kunming City in Yunnan Province by upgrading sewage treatment plants, thereby contributing to the improvement of the living environment in the region through the reduction of water pollutant in Dianchi Lake.

Loan Approved Amount/ Disbursed Amount	I: 12,700 million Japanese yen/12,647 million Japanese yen II: 10,400 million Japanese yen/6,647 million Japanese yen	
Exchange of Notes Date/ Loan Agreement Signing Date	I: June 23, 2006/June 23, 2006 II: March 30, 2007/March 30, 2007	
Terms and Conditions	Interest Rate	0.75 %
	Repayment Period	40 years
	(Grace Period)	(10 years)
	Conditions for Procurement:	General Untied
Borrower / Executing Agencies	The People's Republic of China/ Kunming People's Government	
Final Disbursement Date	May 2016	
Main Contractor	I: Hunan Provincial Construction Engineering Corporation Group, Five Bureau of China Railway (Group) Company Limited II：China National Precision Machinery Import & Export Corp., Zhongtai Construction Group Share Co. Ltd.	

	(all of them are in China)
Main Consultant	-
Feasibility Studies, etc.	F/S: Central and Southern China Municipal Engineering Design and Research Institute, State Power Corporation of China, Kunming Investigation, Design and Research Institute (June 2005)
Related Projects	【ODA Loan】 ・ Dalian Water Supply and Wastewater Treatment Project (2000) ・ Yichang Water Environmental Improvement Project (2002) ・ Nanning Environmental Improvement Project (2002) ・ Huhehaote City Water Environmental Improvement Project (2003) ・ Shaanxi Water Environmental Improvement Project (2004) ・ Water Supply and Quality Environmental Project in Changsha City (2004) ・ Guiyang Water Environmental Improvement Project (2004) 【Other International Organization】 ・ Yunnan Environmental Project (World Bank 1996)

2. Outline of the Evaluation Study

2.1 External Evaluator

Shima Hayase, IC Net Limited

2.2 Duration of Evaluation Study

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

Duration of the Study: July, 2016 – October, 2017

Duration of the Field Study: November 9, 2016 – November 17, 2016, April 14, 2017 – April 17, 2017

2.3 Constraints during the Evaluation Study

Although it is stated that the effectiveness of the sewerage facilities upgraded under this project resulted in "a reduction in aquatic pollutant in Dianchi Lake," it is difficult to directly assess to what level this project contributed to the reduction in water pollutant, as the water quality of the lake was influenced by many factors other than the sewerage facilities upgrade. Therefore, this ex-post evaluation regards a change in the water quality of Dianchi Lake as the impact. And so the contribution of this project will be analyzed by confirming the factors for the reduction in water pollutant and by comparing this to the reduction in the volume of aquatic pollutants as a result of sewage treatment and its ratio of the pollutants discharged into the water of Dianchi Lake.

3. Results of the Evaluation (Overall Rating: A[2])

3.1 Relevance (Rating:③[3])

3.1.1 Consistency with the Development Plan of China

(1) Consistency with the Development Plan at the Time of Appraisal

The 10th Five-year Plan of the People's Republic of China for Economic and Social Development (2001-2005), the national development plan at the time of appraisal, aimed at harmonious economic and social development and placed importance on the improvement of the environment, which had worsened during economic development. *The 10th Five-year Environmental Protection Plan (2001-2005)* specified the following objective concerning sewage treatment and the improvement of surface water quality: an increase in the sewage treatment rate to 45% in urban areas (60% if the population was 500,000 or more, 70% for prioritized cities). The plan regarded prevention of water pollution of "three rivers and three lakes[4]", including Dianchi Lake as a national key project. Moreover objectives from a previous plan were not achieved and *the 11th Five-year Environmental Protection Plan (2006-2010)*, added an objective of a 10% reduction in the total emission of the main pollutants, as compared to the 2015 levels to reduce environmental pollution.

The 10th Five-year Plan of for Economic and Social Development of Kunming City (2001 - 2005) and *the 11th Five-year Plan of for Economic and Social Development of Kunming City (2006 - 2010)* of Yunnan Province and Kunming People's Government specified the following objectives: improvement in the treatment capacity of sewage discharged into Dianchi Lake from the city center, the worst source of water pollution for Dianchi Lake; a reduction in pollutant in the area where further increase in the population is foreseen; limiting water quality worsening to a certain degree; and improvement of the living environment of the people in the city.

(2) Consistency with the Development Plan at the Time of Ex-post Evaluation

The 12th Five-year Plan of the People's Republic of China for Economic and Social Development (2011-2015), specified five propriety fields. Among them is the aim of "resource-saving and environmentally-friendly society". Regarding this aim the plan set the objective of improving the general level of infrastructure, including water supply and drainage and sewage treatment and refuse facilities by a unified urban public facility plan.

In *the 12th Five-year Environmental Protection Plan (2011-2015)*, aiming at preferential

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

[3] ③ High, ② Fair, ① Low

[4] Refers to three rives (Haihe River, Liaohe River and Huaihe River) and three lakes (Tai Lake, Chao Lake and Dianchi Lake) in China. These were designated as national environmental protection reserves by "the Decision Concerning Certain Environmental Protection Issues by the State Council" in August, 1996.

implementation of eight environmental protection projects toward the harmonious development of the economic, social and environmental, three projects were concerned with the improvement of the water environment and the strengthening of construction of sewage treatment infrastructures. Among them, the objectives relevant to this project include: (a) an 8% reduction of chemical oxygen demand (COD) and 10% reduction of ammoniac nitrogen (NH3-N) by 2015, as compared to 2010 (b) strengthening of construction of sewage pipe networks, promoting remodeling of the division of the flow of rainwater and polluted water, an increase in the urban sewage treatment rate to 85%, detoxification of sludge, use of reclaimed water, reducing the level of phosphorus and nitrogen of sewage facilities especially located in basins of Dianchi Lake, Chao Lake and Lake Tai as well as those in other major cities (c) a comprehensive improvement in the water quality of Dianchi Lake, which was rated inferior class V, and rivers flowing into the lake by the following measures: designating the lake as a natural reserve; a restrictive use of the surrounding area of the lake; and conducting watershed protection and measure for water pollution. In response to this, the Yunnan Provincial Government drew up *the Plan for Water Pollution Measure for the Basin of Dianchi Lake (2011-2015)* in order to achieve a national objective of a comprehensive improvement in Dianchi Lake and surrounding areas.

In this way, the strengthening of construction of sewage treatment infrastructures and the improvement of the water quality of Dianchi Lake continued to be the main focuses for the development plan in the state and the city in the period between the appraisal and the ex-post evaluation. Thus, the relevance to this project is high.

3.1.2 Consistency with the Development Needs of China

In Kunming City where all the rivers flow into Dianchi Lake due to its landform, urban development and increase in the population were accompanied by an increase in the volume of sewage. Since 1986 the water quality of the lake has been inferior V, the worst level. Pollution has been in a critical state. According to the F/S, it was foreseen that water would be supplied to an increased population of 2,940,000 and the volume of water sewage would increase to 900,000 m^3/day in 2015. Further water pollutant was a concern.

According to the actual results at the time of the ex-post evaluation (2015), the volume of sewage is 1,504,000 m^3/day (forecast rate 167%) and water-supplied population is 3,940,000 (target rate 134%), which showed a higher growth rate compared with the forecast population of 2,940,000 at the time of the appraisal. As the volume of sewage increases at a pace which exceeds the forecast, further strengthening of the sewage treatment capacity is needed.

Plan for Water Pollution Measure for the Basin of Dianchi Lake (2011-2015) drew up an objective of reducing 6,000t of COD and 2,100t of NH3-N annually for the improvement of the water quality of Dianchi Lake. A contribution to reduction through strengthening of the

sewage treatment capacity was demanded. In this way, the development needs for strengthening of the sewage treatment capacity are still high at the time of the ex-post evaluation, as at the time of the appraisal.

Table 1: Population in Kunming, Foresee and the Actual Results of the Sewage Volume

	F/S Baseline	F/S Prediction		Actual
	2002	2015	2030	2015
Total Population（10,000 persons）	274	320.7	360	402
Water-supplied Population（10,000 persons）	263.7	294	326	394
Sewage Volume（10,000 ㎥/day）	64	90	106	150.4

Source： Baseline and prediction in F/S, actual data submitted by Executing Agency
Note1：The total population included fluid population
Note 2：The forecast of sewage volume was calculated based on water supplied population

3.1.3 Consistency with Japan's ODA Policy

In *the Medium-Term Strategy for Overseas Economic Cooperation Operations (2005-2007)*, and *Country Assistance Policy for China FY2005* among the priority fields, JICA specified the need for improving sewage treatment facilities as a measure against water pollutant for avoiding or reducing the negative environmental impact of infrastructure development.

The above-mentioned 'Country Assistance Policy for China', which required a governmental role, regarded support for upgrading sewage treatment facilities and public projects as priorities. Regarding sewage sectors, it specified a policy to support the improvement of items the Chinese Government specified as policy challenges such as a comprehensive improvement of the water use efficiency through the improvement of the treatment rate and the upgrading of sewage facilities and water recycling facilities.

This project aimed at environmental conservation and was relevant to Japan's ODA policy that aimed at a comprehensive improvement of the water use efficiency through the construction of sewage facilities.

In light of the above, this project is fully relevant to the development policies, development needs of the Chinese Government, Yunnan Province and Kunming City and their needs at the time of the appraisal and the ex-post evaluation and to Japan's ODA policy at the time of the appraisal. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

(1) Planning and Results of Project Outputs

Although there were some changes, the project was carried out almost as planned as shown in Table 2. The changes were as follows:

(a) Upgrading of Sewage Network: The total length of extension was 102% of the designed

length, approximately planned. A part of the sewage network was constructed with domestic funds prior to this project. Because of this previous construction, an adjustment was made to this project whereby, as part of this project, the construction length of a storm drain was reduced and instead a sewer culvert was constructed. For the same reason, the number of pump stations constructed was changed. A pump station exempted from this project was constructed with domestic funds. Surplus proceeds from these changes was used for the construction of the sewage network.

(b) Renovation, Expansion and Construction of the Sewage Treatment Plants: Because the 4th Sewage Treatment Plant was on a small site, an ozone-disinfection process which allowed for conducting advanced processes with a space-saved was applied. The ozone-disinfection facility was installed with domestic funds and the construction of a UV facility planned in this project was replaced with the construction of a deodorization facility.

(c) Training: Although 90 people from 8 groups were scheduled to participate in training in Japan, 81 people of 10 groups participated in training because China's policy on travel for government workers became stricter and tour groups were coordinated according to the purposes. The officers including administration and operation managers in charge of the operation and maintenance, and engineers took courses in each field, and training was almost carried out as planned.

Table 2: Comparison of Outputs of the Plan and the Actual Results

Plan		Actual
(a) Upgrading of Sewage Pipe Network		
Sewage Pipe Network: 336 km Installation of Sewage Pump Stations: 9 locations		Sewage pipe network: 342.7 km (+13.7km) Installation of sewage pump stations: 8 locations (-1)
(b) Sewage Treatment Plant		
Name	Content: Renovation, Expansion and New Construction	Results
1st STP A_2O Process[5] 120,000 m³/day	Sludge Treatment Facility	As Planned
2nd STP A_2O Process 100,000 m³/day	Coagulation Settling and Sludge Treatment Facility	As Planned
3rd STP ICEAS Process[6] 1500,000 m³/day	Strengthening Treatment Capacity to 60,000 m³/day Coagulation Settling and Sludge Treatment Facility	As Planned
4th STP ICEAS Process 60,000 m³/day	Repairing UV Facility	Construction of Deodorization Facility
5th STP A_2O Process 75,000 m³/day	Strengthening Treatment Capacity to 95,000 m³/day Coagulation Settling, Sludge Treatment Facility and UV Facility	As Planned
6th STP A_2O Process 50,000 m³/day	Strengthening Treatment Capability to 80,000 m³/day Coagulation Settling and Sludge Treatment Facility	As Planned
7th STP A_2O Process	Construction 200,000 m³/day	As Planned
Total of Existing Capacity 555,000 m³/day Total of Additional Treatment Capacity 435,000 m³/day		Total of Existing and Additional Treatment Capacity 990,000 m³/day
(c) Overseas Training		
8 Groups Total of 90 People		10 Groups Total of 81 People

Source: materials submitted by Executing Agency
* The numbers in parentheses show a change in actual

Sludge Treatment Facility (the 1st STP)

Deodorization Facility (the 4th STP)

[5] Anaerobic Anoxic Oxic is a sewage treatment process, which removes more nitrogen and phosphorus, major causes for eutrophication in lakes, ponds and seas, more than the conventional activated sludge process, which is generally applied.
[6] Intermittent Cycle Extended Aeration is a sewage treatment process where biological treatment, sludge settling and discharging supernatant water are applied in the same tank.

3.2.2 Project Inputs

3.2.2.1 Project Cost

At the time of the appraisal, the project cost was estimated to be 52,981 million Japanese yen (25,222 million Japanese yen in foreign currency; 27,759 million Japanese yen in domestic currency). The actual cost was 43,820 million Japanese yen (19,114 million Japanese yen in foreign currency; 24,706 million Japanese yen in domestic currency), 83% of the planned cost at the time of the appraisal. The reasons why the actual cost was lower than the planned out was as follows: the cost for material and equipment were lower than the planned cost; the construction cost was lower than the planned cost as a result of competitive bidding; and an influence of fluctuations in exchange rates[7].

3.2.2.2 Project Period

At the time of the appraisal, the project implementation period was scheduled from June 2006 to December 2012 (79 months). The actual project was from June 2006 to May 2016 (120 months), 152% of the planned period, thus the project period was significantly longer than planned. Since the construction of a sewage pipes network was needed to coincide with road works in Kunming City, the project implementation period was significantly extended. The period of the road construction in the area where the network of sewage pipes were constructed was later than the assumption at the time of appraisal. Therefore it was delayed. However, because renovation, expansion and construction of the sewage treatment plants were conducted as planned, and sewage collection was possible with a network of sewage pipes and pump stations installed with domestic funds; the delay did not have negative effect on the project's effectiveness. The period of overseas training was also significantly extended because China's policy on travel for government workers became stricter.

3.2.3 Results of Calculations of Internal Rates of Return (Reference only)

The financial internal rate of return (FIRR) was recalculated with the actual costs and benefits which were submitted by Executing Agency. Although it was 5.5% at the time of the appraisal, the result was 7.4% (Table 3). This was because, compared with the plan at the time of the appraisal, the volume of sewage treatment was larger at the time of the ex-post evaluation, and the sewage treatment revenue[8] gained according to the volume which was higher than planned. In addition, it was because the project cost was below the planed cost.

[7] At the time of appraisal (2004), calculation was made at a rate of 13.7 yen per Chinese yuan. However, as a period of time between 2006 and 2016 when expenses occurred the exchange rate shifted between 14.68 and 15.58 Japanese yen to Chinese yuan, the total projected cost in Japanese yen became smaller.

[8] The sewage treatment plants treat domestic wastewater as well as rainwater, which flow into sewages. As the cost for treating rainwater cannot be collected, subsidies from the municipal government are used. Thus the sewage treatment fee revenue consists of sewage treatment charge and subsidies.

Table 3: Comparison of FIRR at Appraisal and the Actual Results

Plan at Appraisal (2004)	Actual (2015)
5.5%	**7.4%**
Prerequisite Cost: Project Cost, Operation and Maintenance Benefit: Sewage Treatment Fee Revenue Project Life: 30 years	**Prerequisite** Cost: Project Cost, Operation and Maintenance Benefit: Sewage Treatment Fee Revenue Project Life: 30 years

Source: FIRR at the time of appraisal on materials submitted by JICA. The evaluator calculated the actual FIRR according to the data provided by Executing Agency.

In light of the above, although the project cost is lower than planned, the efficiency is fair because the project period is far longer than planned.

3.3 Effectiveness[9] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

The improvement in the capability of the sewage treatment in the city center of Kunming City was expected as the quantitative effects of the Project. The targets in three years after completion (2015) were set for the sewage treatment population, the volume of sewage treatment and the sewage treatment ratio in the whole city[10]. Although at the time of the appraisal the targets for sewage treatment capacity in each of the sewage treatment plants were not set, a comparison between the volume of sewage treatment and the designed capacity was used to confirm if each of the sewage treatment plants demonstrated their expected capacity.

3.3.1.1 Operation Indicators

(1) The Sewage Treatment Volume and the Rate in Kunming City

While the sewage treatment population in the center of Kunming City was the target ratio of 125%, the sewage treatment volume was the target ratio of 167%. Treatment capability was much higher than the target. The result of the sewage treatment rate tied with the target.[11] Therefore, it can be stated that all of the sewage treatment population, sewage treatment volume and the rate were higher than expected. (Table 4)

[9] Sub-rating for Effectiveness is to be put with consideration of Impact.

[10] The project completion year was 2016, however, because the completion of renovation, expansion and construction of the sewage treatment plants was October, 2010, the construction completion year was regarded as 2011. As planned at the time of the appraisal, the completion of this project was set on as one year after terms of warranty (2012). The degree of performance was checked by a comparison between the results in 2015, three years after completion, and the target data.

[11] While the target of the sewage treatment ratio under this project was 99.8%, the result in 2015 was also 99.8%. In table 4, the data became 100%, being rounded off to one decimal place.

Table 4: Target and the Actual Results[12] of the Sewage Treatment Volume, the Rate, Sewage Treatment Population

	unit	Baseline	Target	Actual				
		2004	2015	2011	2012[13]	2013	2014	2015
		Appraisal Year	3 years After Project Completion	Completion of Sewage Treatment Plant Upgrade	Project Completion Year	1 year after Project Completion	2 years After Project Completion	3 years After Project Completion
Number of Sewage Treatment Plants	locations	6	7	7	7	9	9	12
Volume of Sewage Water	10,000m^3 /day	68.8	90.2	114.3	106.0	133.4	141.7	150.4
Volume of Sewage Treatment	10,000m^3 /day	46.4	90.0	97.8	94.3	123.3	136.0	150.1
Sewage Treatment Rate	%	67%	100%	86%	89%	92%	96%	100%
Volume under this Project	10,000m^3 /day	46.4	90.0	97.8	94.3	94.8	104.6	111.1
Ratio of this Project	%	100%	100%	100%	100%	77%	77%	74%
Population	10,000 persons	281	322	352	364	376	389	402
Sewage Treatment Population	10,000 persons	197	315.2	303	324	345	369	394

Source: Materials submitted by Executing Agency

The sewage treatment plants provided under this project treated 74% (111,100 m^3/day) of the total volume of sewage in the center of Kunming City as of 2015. Thus, it can be stated that these facilities fulfilled significant roles as the core of the sewage treatment system in Kunming City.

(2) The Treatment Volume of the Seven Plants[14] under the Project, the Sewage Treatment Rate, and the Plant Operation Rate[15]

The sewage volume flowing into each of the treatment plants improved by the project is higher than the volume estimated at the time of appraisal. In the target year, except for the 4th Sewage Treatment Plant, the volume treated at the rest of the six sewage treatment plants exceeded the designed capacity. As the actual treatment capacity was set up adding 10-20%

[12] The volume of sewage water and the volume of sewage treatment are the average volumes at the end of the year in the urban area of Kunming City. The volume of sewage water is calculated by multiplying annual consummation of tap water by certain coefficients. The inlet amount at the sewage treatment plants is consisted of discharged sewage water and others (rainwater and ground water). The sewage treatment rate is calculated by dividing the volume of sewage treatment by the volume of sewage water. The population represents the whole population of the urban area of Kunming City and the sewage treatment population represents the population, connected to sewage treatment service.

[13] As the rainfall amount in Kunming City in 2012 was less than a normal year, the collected sewage volume and the volume of sewage treatment were less than the previous year.

[14] The population covered by each of the sewage treatment plants and the sewage treatment population were not be used for the ex-post evaluation of this project for the following reasons: the sewage treatment areas were not in accordance with the local government's jurisdiction; and the numbers of meters were not in accordance with the number of households.

[15] Because the plant operation rate (how much each plant is used in comparison with its capacity) was not used as an operational effect indicator at the time of the appraisal, it was calculated as a reference for this ex-post evaluation.

extra, no problem occurred. Thus it can be said that the state of treatment was more than the expectation. In case when the inflow volume exceeded the actual treatment capacity due to unexpected heavy rains or other reasons, an adjustment was made by simplifying processes such as shortening settling time as an emergency measure, and then discharging the water into rivers. Permission was given for this measure by the Environmental Protection Bureau. As it was conducted observing water quality standards, it did not have any negative impact on the environment.

Table 5: Wastewater Treatment Volume, Facility Utilization Rate[16] of STPs

Baseline (Appraisal Year : 2005)							
Sewage Treatment Plants	1st STP	2nd STP	3rd STP	4th STP	5th STP	6th STP	7th STP
Design Capacity (10,000 m^3/day)	12.0	10.0	15.0	6.0	7.5	5.0	—
Wastewater Treatment Volume (10,000 m^3/day)	9.6	8.5	14.4	6.4	6.6	1.1	—
Rate (%)	100%	100%	100%	100%	100%	100%	—
Facility Utilization Rate (%) (Reference)	80%	85%	96%	107%	88%	18%	—
Actual (3 Years After Project Completion: 2015)							
Sewage Treatment Plants	1st STP	2nd STP	3rd STP	4th STP	5th STP	6th STP	7th STP
Design Capacity (10,000 m^3/day)	12.0	10.0	21.0	6.0	17.0	13.0	20.0
Wastewater Treatment Volume (10,000 m^3/day)	13.4	11.4	22.6	5.7	23.6	13.4	21.1
Sewage Treatment Rate (%)	100%	100%	100%	100%	100%	100%	100%
Facility Utilization Rate (%) (Reference)	112%	114%	108%	94%	128%	103%	105%

Source: Baseline data on material submitted by JICA. Actual data on materials submitted by Executing Agency.
Note：As the 7th Sewage Treatment Plant was newly constructed. There is no baseline data of 2005.

Reaction Tank in the 5th STP

Reaction Tank in the 6th STP

[16] Design capability is a daily maximum volume of treatment, wastewater treatment volume is a daily average of annual treatment volume, facility utilization rate of sewage treatment plants is calculated by daily average treatment volume by design capacity

(3) Use and Reuse of Discharged Water

At the time of the appraisal the target was not set for indicators regarding reclaimed water. In reality, the whole volume of the discharged water (annual volume of sewage water was approximately 400,000,000m^3 in the 2016 data) after treatment in the sewage treatment plants upgraded by this project, is conducted advanced processing. Then 98.6% is used as river scenic water for the purpose of river cleaning and odor control, and 1.4% is used as urban recycling water for greening in parks, sprinkling water for roads, car washing water, toilet water and industrial water. Among the urban recycling water, 95% has been transported by reclaimed water pipes and the rest of 5% has been transported to usage points by sprinkler trucks. As Kunming City where urbanization has been increased and facing water shortages, the expanded use of reclaimed water is promoted as an additional water source other than precipitation. The recycling of the discharged water from the sewage treatment plants is worthy of special mention.

3.3.1.2 Effect Indicators

The target value regarding water quality at the time of the appraisal was set only for the biochemical oxygen demand (BOD) concentration of discharged water. In Kunming City, discharged water from sewage treatment plants is required to meet the first-class A national standard[17]. Thus, other indicators of discharged water other than BOD are also compared with the national standard to confirm the achievement level of the effect regarding water quality.

Regarding a change in each indicator (outlet concentration) between 2011 and 2016[18] after the completion of sewage treatment plants upgrade, all the plants including the 1st to the 7th met the first-class A national standard regarding COD, suspended solids (SS), total nitrogen (T-N) concentration, total phosphorus (T-P) concentration, hydrogen ion concentration (pH) and coliform bacilli.[19] Thus it can be stated that expected effects have arisen.

Regarding a change in indicators, BOD concentration (inlet and outlet) and the reduction rate of each of the sewage treatment plants are shown as a sample. (Table 6) Although concentration at the inlet has increased since 2004 before project implementation, the reduction rate has become close to 100%. All the sewage treatment plants are able to fulfill

[17] *Discharge Standard of Pollutants for Municipal Wastewater Treatment Plan（GB18918-2002）*

[18] Since 2010, sewage treatment has been conducting with renovated treatment capacity. The actual data was calculated with the average values between January and December. This evaluation confirmed the target was attained if each indicator regarding outlet concentration from 2011 to 2016 (at the time of the ex-post evaluation) was below the baseline of the first class A national standard.

[19] In 2012, in the 6th Sewage Treatment Plant, T-P outlet concentration was 0.53mg/L, 0.03 mg/L higher than the standard of 0.5mg/L. According to Executing Agency, it was because there was an abnormality of T-P in the sewage which flowed in. While the average T-P concentration was 10.4mg/L, it reached 66.7 mg/L at the highest at the time of abnormality.

the first-class national standard of outlet concentration of 10 mg/L.

Table 6: A Change in BOD Concentration in STP under the Project (unit: mg/L)

the First Class A Grade: Outlet Concentration below 10 mg/L		Baseline	Actual					
		2004	2011	2012	2013	2014	2015	2016
		Appraisal Year	Year of STP Upgrade Completion	Project Completion	1 year After Project Completion	2 years After Project Completion	3 years After Project Completion	4 years After Project Completion
1st STP	Inlet	115.0	230.4	170.5	333.6	265.1	209.6	261.3
	Outlet	9.1	4.1	1.5	1.3	1.0	1.1	0.8
	Reduction Rate	91%	98%	99%	100%	100%	99%	100%
2nd STP	Inlet	83.9	121.9	107.4	114.3	99.7	161.6	122.1
	Outlet	9.8	2.0	1.3	1.2	0.9	1.3	1.0
	Reduction Rate	88%	98%	99%	99%	99%	99%	99%
3rd STP	Inlet	137.3	299.2	425.2	238.3	163.3	162.3	115.4
	Outlet	14.0	4.5	1.9	1.5	1.5	1.4	1.0
	Reduction Rate	90%	99%	100%	99%	99%	99%	99%
4th STP	Inlet	135.9	93.5	85.1	130.8	130.1	193.0	180.9
	Outlet	4.7	1.5	1.5	1.5	1.4	1.7	1.0
	Reduction Rate	97%	98%	98%	99%	99%	99%	99%
5th STP	Inlet	125.1	192.3	181.0	198.0	203.9	162.9	196.5
	Outlet	7.9	1.6	1.3	1.6	1.2	1.0	0.8
	Reduction Rate	94%	99%	99%	99%	99%	99%	100%
6th STP	Inlet	114.5	441.9	251.9	193.2	177.0	150.4	161.1
	Outlet	7.5	1.7	2.0	1.2	1.1	1.1	1.0
	Reduction Rate	93%	100%	99%	99%	99%	99%	99%
7th STP	Inlet	—	236.0	222.0	197.9	147.2	156.6	188.6
	Outlet	—	1.7	1.2	1.0	1.0	1.2	0.9
	Reduction Rate	—	99%	99%	99%	99%	99%	100%

Source: Material submitted by Executing Agency
Note: At the time of the appraisal, target value for the quality of discharged water (BOD concentration) was set below 10mg/L (3 years after the project completion: 2015)
Note 2: Both inlet and outlet concentrations are annual average volumes, which are automatically measured daily by water quality monitoring devices set by third parties.

In light of the above, Kunming City has largely fulfilled the targets for the sewage treatment volume and the sewage treatment rate. Each of the sewage treatment plants treats wastewater at standards higher than expected. Although the facility utilization rate is above 100% at all treatment plants, except for the 4th Sewage Treatment Plant, adjustment of load is made within a range which does not have an impact on the environment. Discharged water after sewage treatment is 100% utilized. Additionally, due to the reason that the effect indicators have been fulfilled, it can be judged that quantitative effects have arisen in the project as a whole.

3.3.2 Qualitative Effects (Other Effects)

At the time of the appraisal, although it was stated that qualitative effects were "improvement of the living environment in Kunming City", it is regarded as the impact level of this project and integrated into "3.4 Impact".

3.3.2.1 Effect of Training[20]

According to the participants of the training in Japan, targetting the officers in charge of the operation and maintenance of the sewage treatment plants, the texts used in the training were incorporated into manuals of Kunming Dianchi Investment Liability Limited Company and its subsidiaries. The method of operating and maintaining treatment, odor control, and tidying-up in the plants they visited in Japan were added to the design and the operation. In addition, in recent years the operation and maintenance company gives technical guidance in other provinces and neighboring countries. Their experience from the training in Japan was also used for technical guidance.

In the sewage treatment plants they visited during their training in Japan, the acceptance of study tours and field trips was a service provided actively. Referring to the Japanese sewage treatment plants, study tour course was built in the 7th Sewage Treatment Plant. At the time of the ex-post evaluation, the plant was accepting approximately 6,000 visitors in a year. The experience of visiting the Japanese plants was used for accepting field trips of primary and junior high schools, cooperation for university students' research and study trips from other cities. According to the participants, after their training in Japan, they have placed higher importance on publicity and environmental education. They not only wait for requests from schools but also have been calling actively on schools to conduct field trips.

In light of the above, the targets for the followings were achieved: the sewage treatment rate in Kunming City; the sewage treatment population and the percentage of sewage treatment population; the operation indicators, such as the operation rate of each treatment plant; and the quality of discharged water as the effect indicator. Therefore, it can be stated that the effects of this project have arisen.

3.4 Impacts

3.4.1 Intended Impacts

"Reduction in water pollutant of Dianchi Lake" and "improvement of the living environment of the residents in the area" were the impacts expected by the project. Regarding them, changes

[20] Based on the training reports and interviews with the participants. Due to personal changes, the interview subjects were not available and only two were interviewed.

in the water quality of Dianchi Lake and the contribution of this project were analyzed. In addition, a beneficiary survey was conducted concerning changes in the lake environment and the living environment, and the state of emergence of project's impact was confirmed.

3.4.1.1 Reduction in Water Pollutant of Dianchi Lake and the Contribution of the Project

(1) Reduction in Water Pollutant at Dianchi Lake

Since 1986, the water quality of Dianchi Lake had been inferior class V. In 2016, for the first time in 30 years, it improved to class V[21]. According to staff of the Environmental Protection Bureau, eutrophication standard[22] of the lake improved from heavy, the worst in 6-grade evaluation to intermediate, and sometimes slight in 2016. Although bacterial growth took place in almost all areas of the lake 30 times annually, it improves to an occasional partial growth in a small area.

According to the officer at the environmental monitoring center, the following are factors for the improvement. Kunming City designated the periphery of Dianchi Lake as a protected area under *the Plan for Water Pollution Measure for the Basin of Dianchi Lake (2011-2015)*, and houses and pollution sources (agriculture, livestock, industry) were moved from the periphery of the lake to suburban areas; regulating sailing and fishing in the lake; and promoting protection of swamp and greening in the periphery. In addition, changing water of the lake took place more frequently from every 8 years to 5 year. Since December 2013, frequency has been increased from every 5 years to every 3 years. Improving water quality by introducing 500,000,000 to 600,000,000 m^3per year to the lake was also a contributing factor to the improvement in eutrophication (phosphorus, nitrogen). The officer explained that the pollution source of Dianchi Lake was mainly domestic wastewater from the urban area (70%) and agricultural diffused source (30%) , and that the largest factor was that the domestic waste water which occupied 70% of pollution source did not flow into the lake any more due to the spread of sewage treatment service.

(2) Change in Water Quality of Dianchi Lake

The major pollutant data of Dianchi Lake (Caohai[23], Waihai[24]) between 2006 and 2015 was submitted by the Environmental Protection Bureau Observation Station. The change of the pollutants flow into the Dianch Lake was analyzed with the water quality data after being

[21] Related articles were published in the People's Daily on Feb. 9, 2017.

[22] Standard set by China's Environmental Protection Bureau. Based on values of COD_{Mn}, T-P, T-N and chlorophyll, the state of lake is classified by 6 levels as follows: heavy eutrophication; intermediate eutrophication; slight eutrophication; eutrophication; middle nutrition and poor nutrition.

[23] The north side of Dianchi Lake, where water in the city center flows in, water pollution was serious because it was a small area and it was shallow.

[24] On the south side of Dianchi Lake the water depth is 5-6 meters. It occupies the majority of the lake.

adjusted by the coefficient of the precipitation[25]. The result of the analysis showed a reduction in T-N concentration, T-P concentration and NH3-N concentration both in Caohai and Waihai. Particularly, in Caohai where water flows into from the city center, a significant change has been observed since 2009.[26] In 2015, T-N concentration was reduced by 39% from the 2006 levels. T-P concentration was reduced by 14% from the 2006 levels. NH3-N concentration was reduced by 12% from the 2006 levels. However, BOD and COD, which are influenced by the climate, the growth of microbes and algae, did not show a significant change during the period as microbes could live in mud at the bottom of the lake for a long period of time.

In Kunming where the climate is stable, as natural impacts such as transpiration are small, the water quality data[27] after being adjusted with rainfall mainly reflected a change in a total lord of pollutant, which flows in. Comparing with adjusted value before the project and adjusted value after the project (2011 onwards), it is analyzed that this change is caused by an artificial factor, that is the influence of the improvement of sewage treatment rate. It is assumed that the project has contributed to the improvement in water quality in Dianchi Lake as 100% of sewage water discharged in the city center of Kunming City has started to be treated at the period of the plants construction completion in 2011. As a sample, the analysis of T-N concentration is shown in figure 2. (Refer to Attachment for a figure of other pollutant lords.)

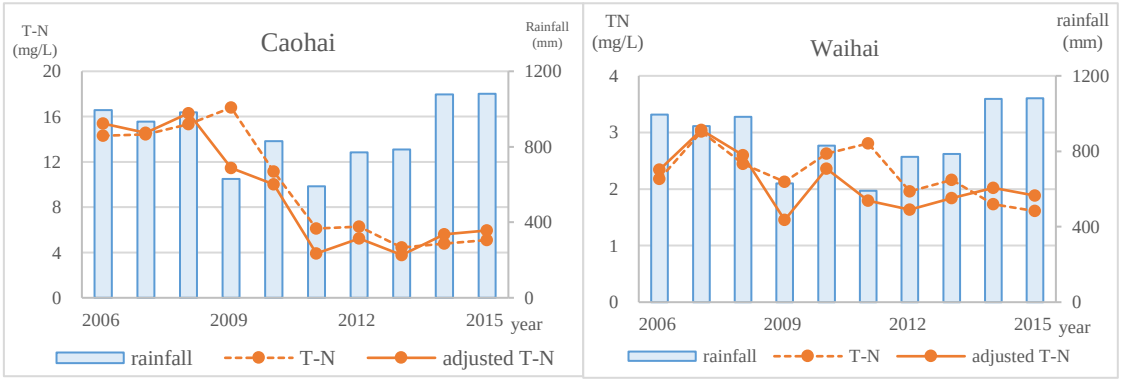


Figure 2: A change in T-N value in Dianchi Lake (Caohai: left) and Dianchi Lake (Waihai: right)

[25] Taking account of a change in rainfall of each year, actual value of water quality was adjusted with the following calculation. Adjustment factor=P_i/ P_{ave} , P_i/= rainfall in the first year, P_{ave} =annual average rainfall. Water quality value after adjustment = submitted data x adjustment factor.

[26] Waihai is 100 times larger than Caohai in size and water volume. As water may come in via Caohai, originally pollution was less than Caohai. Not much change was observed.

[27] Generally speaking, pollutant lord concentration is not only influenced by concentration flow in but also directly by water storage volume. Although water storage volume is influenced by evaporation and rainfall, temperature change rate has been approximately 0.1 and evaporation rate has been hardly changed through the year in Kunming City for the last 10 years. However, as a change in rainfall volume has been large, adjusting the water quality, which was submitted, made it possible to compare a change in water quality.

(3) Major Pollutants Load in Kunming City and Contribution by the Project

Regarding the major pollutants [28](COD, T-N, T-P), which were generated in the urban area of Kunming City and were discharged into Dianchi Lake, their reduction by the project (sewage treatment in the 1st to 7th sewage treatment plants) and reduction ratio, a survey on pollutant load generated in the urban area was conducted. The results of 2010 and 2012 are shown in Table 7.

Among the major pollutants in the urban area of Kunming City, the ratios of pollutants reduced by this project are as follows: in 2010, 81% in the case of COD and 61% in the case of T-N, 74% in the case of T-P, in 2012, 83% in the case of COD, 69% in the case of T-N, 78% in the case of T-P. Thus this project has significantly contributed to the reduction of water pollutants.

Table 7: Major Pollutants Generated in Kunming City and Contribution of the Project

Year	Item	COD	T-N	T-P
		t/year	t/year	t/year
Baseline				
2005	Pollutant Load Generated in Urban Area of Kunming City	41,986	9,810	927
Actual				
2010	Pollutant Load Generated in Urban Area of Kunming City	87,192	14,803	1,497
	Reduction Load by the Project	70,573	8,997	1,113
	Reduction Ratio by the Project	**81%**	**61%**	**74%**
2012	Pollutant Load Generated in Urban Area of Kunming City	97,461	16,444	1,662
	Reduction by the Project	81,011	11,322	1,302
	Reduction ratio by the Project	**83%**	**69%**	**78%**

Source: Material submitted by Executing Agency
Note：Separated actual data of Caohai and Waihai were not submitted.

3.4.1.2 Improvement of the Living Environment of Residents

Regarding “improvement in the living environment of residents”, a beneficiary survey[29] (number of valid responses:100) was conducted to study the improvement in the water quality of Dianchi Lake, its having or not having an environmental improvement compared with before the project (2006), and at time of the ex-post evaluation and the degree of

[28] Since the urban area of Kunming City is adjacent to Dianchi Lake, all pollutant lord generated is flowed into Dianchi Lake through a network of discharged wastewater pipes and rives in the city. Thus the lord generated in the urban area is nearly the same amount of the lord flowing into the lake.

[29] A beneficiary survey was conducted and questionnaires covered local residents. The subjects of the survey were those who resided around the discharging points in the rivers where sewage water was discharged from 7 sewage treatment plants; and those who resided near Dianchi Lake. The subjects were a total of 100 residents: 56 residents who resided near discharging points in the six rivers; and 44 residents who resided near Dianchi Lake. Of the respondents, 37% were women and 63% were men and by age group, 25% were in their 20s, 30% were in their 30s, 22% were in their 40s, 14% were in their 50s, 7% were in their 60s, over 70 were 2%.

satisfaction with the sewage treatment service. [30]

According to the results of the beneficiary survey, regarding a change in the environment of Dianchi Lake and the rivers, where effluent water is discharged from the sewage treatment plants, compared with 10 years ago (approximately 2006) and at the time of the ex-post evaluation, more than 95% of the respondents answered that the followings improved respectively: the water quality; floating substances; odor; scenery; inhabitation of birds and fish; plants; the hygiene environment; and the drainage environment. It can be stated that many residents recognized improvement.[31]

More than a half of respondents pointed to the following factors for improvement: drainage; hygiene; and stricter regulations of factories which were sources of wastewater. Concerning the upgrading of the network of sewage pipes and the construction of sewage treatment plants, 43 respondents regarded these as factors for the environmental improvement.

Regarding the degree of satisfaction with the sewage treatment service at the time of the ex-post evaluation, 89% of the respondents answered that they were satisfied. 55 respondents gave "clogged sewage and backwater do not happen" as a reason. Regarding "measures for heavy rains and floods" while eight people gave this for a reason for their satisfaction, 14 people gave this for a reason for their dissatisfaction. Evaluation was diverse. According to the explanations given by Kunming Dianchi Investment Liability Limited Company, the reasons were as follows: a delay in division of sewage pipes and rain water pipes in the city center; and the collection of rainwater in case of heavy rains, which has been a challenge.

3.4.2 Other impacts

3.4.2.1 Impacts on the Natural Environment[32]

(1) Monitoring during Project Execution

At the time of the appraisal, significant negative impact on the natural environment was not assumed. During the renovation, expansion and construction of the sewage treatment plants and the construction of a networks of pipes under this project, as planned at the time of the appraisal, daily inspection was conducted on waste disposal, water pollution, noise and vibration. Also, the monitoring centers at municipal and ward levels conducted monthly

[30] A survey of companies near Dianchi Lake was planned. However, control over companies, which were pollutant sources, was strengthened due to staged amendments to the Dianchi Lake Protection Ordinance, established in 1998. Gradually factories were relocated and there is no factory in the areas. Thus, the beneficiary survey only covered local residents. In addition, because the periphery of Dianchi Lake was designated as an environmental protection reserve and living in the areas were restricted, residents near the sewage treatment plants were included as subjects of the beneficiary survey.

[31] Answers for respective items were as follows: water quality 98%; floating materials 97%; odor 97%; scenery 97%: inhabitation of birds and fish 95%: plants such as trees and flowers 98%; the hygienic state 95%; and the drainage environment 95%.

[32] The project's environmental impact research report was adopted by the State Environmental Protection Ministry in August, 2005.

inspection on the water quality of the sewage. According to Kunming Dianchi Investment Liability Limited Company, the construction was in accordance with the environmental protection standard and there were no issues during the construction.

(2) Monitoring after Project Completion and Environmental Consciousness on the Periphery

All the sewage treatment plants monitor the concentration of pollutants (COD, BOD, SS, T-N, T-P, pH, etc.) in the water for 24 hours by monitors installed at the sewage inlets and outlets. The monitors are managed by a third-party organization specialized in environmental monitoring. The monitoring data are directly sent online to the State Environmental Protection Ministry. In addition, in order to check the precision of the observation equipment, samples are taken and are carried in the laboratory in the 3rd Sewage Treatment Plant, and specialist staff examine the quality of water flowing into and out from the plants every day.

Previously, the peripheries of the sewage treatment plants were farms. However, at the time of the ex-post evaluation houses were built up to on the peripheries. Each sewage treatment plants have installed deodorant facilities and a system where pumps are operated underground so to reduce noise and vibration for consideration. In addition, for consideration of landscape and environment, on the treatment plant premises, trees were planted like in parks.

Sludge generated in the sewage treatment plants is dehydrated to a moisture content of about 80%[33], and is transported to be buried. It is not recycled. The construction of a sludge treatment center is likely to be completed by June, 2018.[34]

(3) Monitoring of Dianchi Lake

At 10 monitoring points for the water quality in Dianchi Lake where automatic inspection devices are installed by Dianchi Lake Monitoring Center monitoring of the water quality (eight criteria) is conducted annually. In addition to this, inspection of the water quality according to 24 criteria by artificial sample collection is conducted once a mouth. As algae grow in the summer time (April to October) in Dianchi Lake, water quality inspection is conducted once a week to inspect the generation of bacteria, which cause eutrophication. The results are sent to the State Environmental Protection Ministry as a weekly and monthly report.

[33] Before 2010, it was dehydrated to a moisture content of 83% and was transported. From 2010 onward, it is dehydrated to a moisture content of 80% to be transported.

[34] The following amounts are planned to be treated: 500t/day in the first stage (2018); 700t/day in the second stage (2020); 1,200 t/day in the third stage (December 2020).

3.4.2.2 Land Acquisition and Resettlement

At the time of the appraisal, it was planned that a total area of 35 ha would be acquired. In reality, a total area of 37.5 ha, 7% higher than the plan, were acquired. As the acquired sites were for agriculture, resettlement did not occur. Following Kunming City's standard, 174,450,000 Chinese yuan were paid as the compensation cost for lands and crop plants.

3.4.2.3 Other Impacts

After sewage treatment, the water from the sewage treatment plants is discharged into rivers in the city and finally flows into Dianchi Lake. The impact of the project is set on the improvement of Dianchi Lake. According to the result of an interview with the project executing agency and according to a beneficiary survey, answers state that odor and muddiness of the peripheries of the rivers have improved. It is assumed that the effects of the sewage treatment provided under this project have also contributed.

According to the Environmental Protection Bureau, the periphery of Dianchi Lake has become a subject for the protection of swamps and forests. In 2016, the swamp area in the lake has expanded 3,600 ha (54,000 mu) in comparison to 10 years ago and the plant coverage rate has increased from 20% in 2004 to 79% in 2015. Bird species have increased from 124 kinds to 138 kinds and fish to 23 kinds. According to the Agricultural Department of Kunming City, water and soil run off has decreased by 30% due to the protection of swamps and forests.

In light of the above, this project has achieved its objectives as planned. Therefore, the effectiveness and impact of this project are high.

3.5 Sustainability (Rating:③)

3.5.1 Institutional Aspects of Operation and Maintenance

To deal with a water quality issue of Dianchi Lake, Kunming City established "Dianchi Lake Protection Commission" in 1990. In 2004, the project's management office "Kunming Municipal Construction and Management Bureau for North Bank Water Environment Treatment Project of Dianchi Lake (KCMB)" was established in the commission and it has controlled the entirety of the project. At the time of the ex-post evaluation, domestic projects concerning the environmental protection of Dianchi Lake are being conducted and the system has not been changed.

Kunming Dianchi Lake Investment Company Limited, a state enterprise 100% owned by Kunming People's Government (hereinafter referred to as "DLICL"), has received a commission from Kunming City and has conducted the renovation, expansion and construction of the sewage treatment plants, covered by the project, under the direction of the

Construction Bureau. Receiving a commission from the city, DLICL has also conducted the operation and maintenance of the completed plants. At the time of the ex-post evaluation, there is no change in the system. However, the operation of the sewage operation plants is conducted by Kunming Dianchi Lake Wastewater Operation Company Limited, a subsidiary established in 2010, (hereinafter referred to as "Wastewater Co."). The operation and maintenance of the network of pipes and pump stations are conducted by Kunming Dianchi Lake Drainage Facilities Company Limited (hereinafter referred to as Drainage Facilities Co.). There is an overlaying chain-of-command structure to the subsidiaries and the division of the roles are clarified. A consistent management system has been established.

Table 8 shows the number of staff in DLICL. Due to the expansion of its business, the number of engineers has increased significantly. Among them are environment engineers, engineers for water resources, architecture, water supply and drainage, ecology as well as legal experts of the water quality environment.

Table 8: Headcount of DLICL (unit : person)

Plan at the time of Appraisal (2006)					At the Time of the Ex-post Evaluation（2016）				
Total	Engineers	Operation	Administration	Accounting	**Total**	Engineers	Operation	Administration	Accounting
28	12	11	3	2	84	63	11	9	1

Source: DLICL

Table 9 shows the number of staff in each plant. According to DLICL, sufficient staff numbers necessary for the operation and maintenance of the plants is in place, including the engineers engaged in the operation and maintenance of the plants, the managers of the monitoring rooms, the patrol staff, and the engineers engaged in water quality inspection. The stuff members in the 2nd, 3rd, 4th, 5th, and 6th sewage treatment plants are fewer than at the time of the appraisal. This is because work that used to be conducted by manpower is now replaced by atomization. No issues have occurred with the operation and maintenance.

Table 9: Headcount of Each Sewage Treatment Plant's Production Department (unit: person)

	Plan at the Time of the Appraisal (2006)					At the Time of the Ex-post Evaluation (2016)				
	Total	Engineers	Operation	Admini-stration	Management	**Total**	Engineers	Operation	Admini-stration	Management
1st STP	30	4	2	2	22	31	4	2	2	23
2nd STP	32	4	2	2	24	30	4	2	2	22
3rd STP	42	6	2	2	32	38	5	2	2	29
4th STP	30	4	2	2	22	24	3	1	2	18
5th STP	32	4	2	2	24	26	4	2	2	18
6th STP	31	5	2	2	22	29	4	1	2	22
7th STP	—	—	—	—	—	24	4	2	1	17
Total	**197**	**27**	**12**	**12**	**146**	**202**	**28**	**12**	**13**	**149**

Source: Material submitted by Executing Agency

At the time of the ex-post evaluation, the number of engineers at Wastewater Co., who are in charge of maintenance of the facilities, is 255[35]. They maintain a network of pipes, 4,300km long in the city center of Kunming City, including the outputs of the project, 93 pump stations and 17 storm-water reservoirs for flood control. According to DLICL and Wastewater Co., sufficient staff numbers necessary for the operation and maintenance of the pipe network and pump stations, including mangers and engineers is in place.

To sum up, no issues have been observed in institutional systems of operation and maintenance.

3.5.2 Technical Aspects of Operation and Maintenance

In DLICL, there are engineers who have experience in designing sewage treatment plants, in operation and maintenance, and in repair and expansion since the 1980's. When its subsidiaries are established, these engineers are transferred to the subsidiaries and they also transfer their techniques to newly hired engineers. Every year, in-house technical training and training to respond to emergencies are held. The engineers who operate and manage sewage treatment plants, network pipes and pump stations are required to acquire qualifications as technicians[36]. Because there is a term of validity for the licenses and the renewal of the licenses requires undergoing training and examination, the technical level has been maintained.

[35] Of permanent staff members of Wastewater Co., the number of the engineers of the production department which is in charge of operation and maintenance are as follows: 120 (engineers: 42; senior engineers: 32; middle-class engineers: 9; and junior engineers: 37.) Besides the permanent staff, for a maintenance purposes, 200 employees are hired for cleaning the network of pipes in the city.

[36] Related technical qualifications include sewage treatment engineering, water quality chemical experimentation, electrical work, elevator and handling pumps.

Sewage treatment technology in Wastewater Co. is at a high level even in China[37]. The company's business expansion is underway as follows: acceptance of inspection; technical guidance in other provinces and neighboring country Lao People's Democratic Republic; joint research with the United States of America; and joint operation and management of sewage treatment plants in other provinces and overseas.

In light of the above, no issues have been observed in the technical aspects of operation and maintenance.

3.5.3 Financial Aspects of Operation and Maintenance

The operation of sewage treatment plants is under an outsourcing agreement (patent management rights) with the city. The revenue of the sewage treatment plant consists of a sewage treatment fee and subsidies from the city. The whole balance of all the seven sewage treatment plants after 2012 is shown in Table 10. Both the whole revue, consisting of sewage treatment fee and subsidies, from all the seven sewage treatment plants and a separate revenue from each plant exceed the operation and maintenance expenses.

Table 10: Revenues from all the seven sewage treatment plants

(Unit：10,000 Chinese yuan)

		2012	2013	2014	2015	2016
Expenses	Operation, Maintenance Cost	18,230	22,503	25,707	27,187	26,165
Revenue	Sewage Treatment Cost	20,727	21,315	22,871	22,911	22,000
	Subsidies from the City	38,680	39,035	43,295	47,185	46,730
Balance		41,178	37,847	40,459	42,909	42,565

Source: Material submitted by Executing Agency
Note: Data in 2016 covers until Sept. 30.

At the time of the appraisal, the sewage treatment fee[38] in the city center of Kunming City was 0.8 Chinese yuan/m^3. In 2009, it was revised as follows: domestic wastewater was 1.00 Chinese yuan/ m^3, wastewater from government, commerce and industries was 1.25 Chinese yuan/m^3. The municipal government has entrusted its sewage treatment service business to DLICL for 30 years, from 2011 to 2041, and during this period, the sewage treatment cost[39] of 1.58 Chinese yuan/m^3 is guaranteed by the municipal government. This amount was calculated with the treatment cost set according to the size of each sewage treatment plant at the end of 2009, with an additional 10% for asset repair expenses. According to DLICL, it is sufficient as operation and maintenance costs.

[37] In 2013, the 3rd and 7th of the sewage treatment plants were selected as 10 of the best sewage treatment plants in the country for their energy-saving performance and reclaimed water use. The 1st sewage treatment plant was commended for its excellent standards, the 2nd, the 4th, 5th, and 6th sewage treatment plants were commended as pioneering plants.

[38] Since sewage treatment bills are charged by pay-as-you-go system along with water charges, the collection rate is nearly 100%.

[39] It is likely to be revised taking the inflation rate into consideration in 2017. Patent management rights will be renewed if there are no issues with operation and maintenance.

In light of the above, there are no issues in sustaining the financial aspect of the operation and maintenance.

3.5.4 Current Status of Operation and Maintenance

The status of the operation and maintenance of the sewage treatment plants provided under this project were studied by interviews with the operation and maintenance companies and the engineers during the field survey.

Both DLICL and its subsidiaries revise their mid-term operation and maintenance plans based on the urban development plans of the national government and Kunming City. Regarding each sewage treatment plant and pipe network, an operation plan was drawn up in accordance with the sewage treatment master plan of the city. Upgrading and repairing of the facilities are also being conducted. At the time of the ex-post evaluation, the capacity rate of each treatment plant exceeds 100%. However, problems do not occur for the following reasons: the actual treatment capacity is set up adding extra capacity; and in case of emergency such as heavy rains when the inflow volume exceeds the actual treatment capacity, the whole volume is treated without having a negative environmental impact. Moreover, the construction of two new treatment plants are planned for the city by 2020. The capacity rate is therefore likely to be eased.

The existing sewage treatment plants (the 1st to the 6th sewage plants), where renovation and expansion were conducted according to this project, and the newly established 7th plant, all treat the volume according to the project plan and the national water quality standard as mentioned in the Effectiveness Section. Each facility has been put in order and complete manuals, patrol records and control room records are being kept.

According to the control rooms engineers, among operational issues, the major issue occurs when water exceeding the designed capacity flows into the plants in case of heavy rains. After getting permission from the Environmental Protection Bureau, a whole process is conducted with adjustment, including shortening treating time and simplifying the treatment process. Then water is discharged into rivers. So they can manage emergency situations while considering the environment.

The water quality of the sewage flowing into the sewage treatment plants and the discharged water are checked by a third organization with installed inspecting devices by every two hours. In addition, samples of water quality are collected by a car and they are inspected in a laboratory in the 3rdSewage Treatment Plant where a manual inspection is conducted. So the water quality is checked twice.

Water Quality Monitoring Device Operated by a Third-party

Control Room in the 7th STP

Regarding the facilities in the sewage treatment plants, periodical cleaning is conducted and the frequency of inspection is set. Cleaning and inspection are conducted as follows: pumps and reaction tanks are overhauled and cleaned once a year; sedimentation drain is cleaned monthly; and the MBR membrane of the 4th Sewerage Treatment Plant is cleaned every week. Dumped refuse across town flow into the network pipes. To avoid being clogged, 1,000 km, one fifth of the whole length, is cleaned every year.

Although some foreign parts have been introduced in the sewage treatment plants and pump stations, there are no problems in acquiring them because they can be secured through domestic agencies. In the sewage treatment plant and pump stations, electric power supply is secured. In case of power failure, the electric power supply is secured by switching the power source to an electric power transmission pathway of a different electric generating station.

The upgraded facilities in accordance with the project are kept in a condition whereby their expected capacity is demonstrated. Thus, it can be stated that the state of operation and maintenance is good.

In light of the above, no problems have been observed in the institutional, technical, and financial aspects of the operation and maintenance. Therefore, the sustainability of the project effects is high.

4. Conclusion, Lessons Learned, and Recommendations

4.1 Conclusion

The objective of this project is to improve the sewage treatment capacity in the city center of Kunming City in Yunnan Province by upgrading sewage treatment plants, thereby contributing to the improvement of the living environment in the area through the reduction of water pollutant in Dianchi Lake.

This project was consistent with China's development policies and development needs at the national, provincial, and municipal levels; in accordance with Japan's policy for assistance to

China at the time of the appraisal. Therefore, its relevance is high. Expected effects have arisen because indicators for the main effects, such as the sewage treatment rate and the quality of the treated water, have achieved the targets. In 2016, for the first time in 30 years the water quality of Dianchi Lake which had been inferior class V, the lowest water quality standard, improved to class V. Reinforcing the sewage treatment capacity resulted in improvement of the quality of water discharged. The effectiveness and impact of this project are significantly high, because this project widely contributed to a decrease in the major pollutants discharged from the urban district of Kunming City into Dianchi Lake. The renovation of the sewage treatment plants, the expansion, the new establishment and construction of the pump stations and pipe network were conducted as scheduled and the project cost was lower than planned. A considerable delay was caused in the project period so that the efficiency of the project is fair. Regarding the sustainability of the effects that arose from this project, there are no problem in the operation and maintenance structure of the managing agency, the technological, and financial aspects. Therefore, the sustainability of the project is high.

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

4.2 Recommendations

None

4.3 Lessons Learned

(1) Need for Cooperation with Related Departments on Environmental Improvement Projects

The water quality of Dianchi Lake had been inferior class V, the lowest water quality standard, since 1986. For the first time in 30 years, it has improved to class V. Promoting the sewage treatment service has reduced the pollutant load flowing into Dianchi Lake. Collaboration with KCMB, the Environmental Protection Bureau and the municipal government on environmental regulations was effective as well. KCMB serves as a secretariat. The deputy mayor holds the post of the chief of KCMB as well and demonstrates strong leadership as bureau chief. KCMB gets the full cooperation of the Environmental Department, with which it is usually hard to build a cooperative relationship in China. The improvement in the water quality of the lake is regarded as a national key project. The following effective measures have been taken by Kunming City: regulating sailing and fishing in the lake; removing pollution sources (agriculture, livestock, industry) and houses from the periphery of the lake; protection of swamp; greening in the periphery; and changing the water of the lake. In projects, which require comprehensive measures such as environmental improvement, policies and measures to reduce environmental load are necessary along with the development of the physical progress of renewing the environment. In order to realize these in a comprehensive manner, a collaborative system with related departments

such as the departments of environmental protection, finance, agriculture, fishing and housing is inevitable.

(2) Fine Example of Expanded Use of Reclaimed Water

Kunming City, where urbanization has increased, sometimes faces water shortages, so that expanded use of reclaimed water is promoted as an additional water source other than precipitation. The discharged water after treatment in the sewage treatment plants, upgraded by this project, is conducted advanced processing. Then 98.6% of the effluent water is used as river scenic water for river cleaning and odor control and 14% is used as urban recycling water for greening in parks, sprinkling water for roads, car washing water, toilet water and industrial water. Among the urban recycling water, 95% is transported by reclaimed water pipes. Some municipal governments are negative regarding the development of the reclaimed water network pipes because of a high cost. In a state when the reuse of reclaimed water has not advanced, the case of Kunming City can be described as a pioneering verification example.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
Sewage Pipe Network	Sewage Pipe Network: 336 km Sewage Pump Stations: 9 Locations	Sewage Pipe Network: 342.7 km Sewage Pump Stations: 8 Locations
Sewage Treatment Plant		
1st STP	Sludge Treatment Facility	As Planned
2nd STP	Coagulation Settling and Sludge Treatment Facility	As Planned
3rd STP	Strengthening Treatment Capacity to 60,000 m^3/day, Coagulation Settling and Sludge Treatment Facility	As Planned
4th STP	Repairing UV Facility	Replaced to Deodorization Facility Construction
5th STP	Strengthening Treatment Capacity to 95,000 m^3/day, Coagulation Settling, Sludge Treatment Facility and UV Facility	As Planned
6th STP	Strengthening Treatment Capability to 80,000 m^3/day, Coagulation Settling and Sludge Treatment Facility	As Planned
7th STP	Construction 200,000m^3/ day	As Planned
Training	8 groups total of 90 people	10 groups total of 81people
2. Project Period	June 2006 to December 2012 （79 months）	June 2006 to May 2016 （120 months）
3. Project Cost		
Foreign Currency Local Currency Total	25,222 million Japanese yen 27,759 million Japanese yen (2,026 million Chinese yuan) 52,981 million Japanese yen	19,114 million Japanese yen 24,706 million Japanese yen (1,654 million Chinese yuan) 43,820 million yen
ODA loan portion	I: 12,700 million Japanese yen II：10,400 million Japanese yen	I：12,647 million Japanese yen II：6,647million Japanese yen
Exchange Rate	1 Chinese yuan＝13.7 Japanese yen (As of September 2005)	1 Chinese yuan=14.94 Japanese yen (Actual average between 2006 and 2016)
4. Final Disbursement Date I：December 2013／II：July 2015		

Attachment 1:　Impact Change in Water Quality of Dianchi Lake

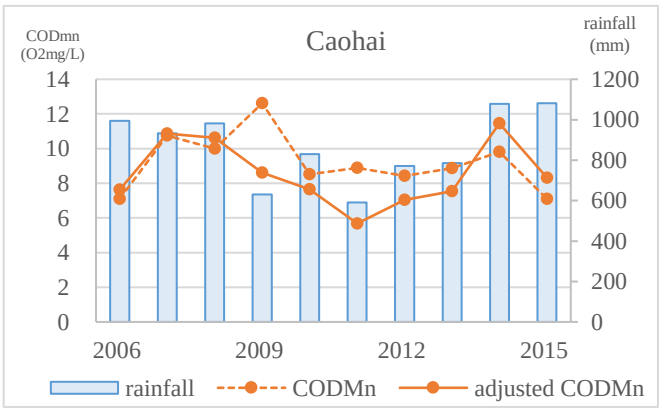
Analysis Method

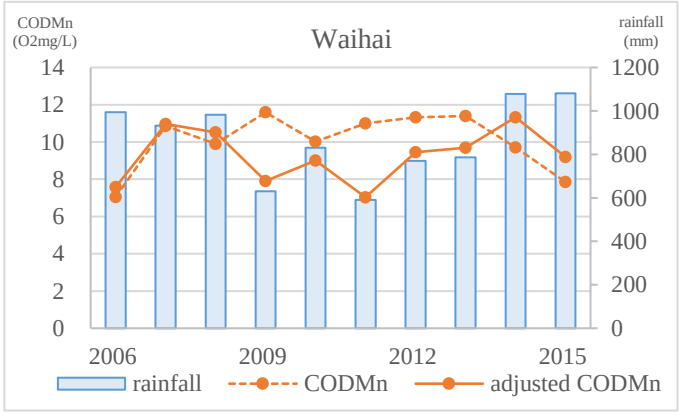
(1) Change in water quality of Dianchi Lake (Caohai, Waihai) between 2006 and 2015 was analyzed. The major pollutant (COD、BOD、T-N、T-P、NH3-N) concentration data was submitted by the Environmental Protection Bureau Observation Station as the average concentration (Caohai, Waihai) ,which was the integrated data of the observation points.

(2) Taking account of a change in rainfall of each year, actual value of water quality was adjusted with the following calculation.

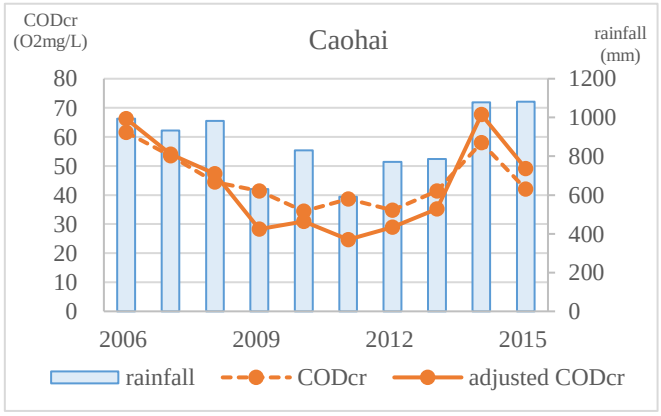
Adjustment factor=P_i/ P_{ave} , P_i/= rainfall in the first year, P_{ave} =annual average rainfall.
Water quality value after adjustment = submitted data x adjustment factor.

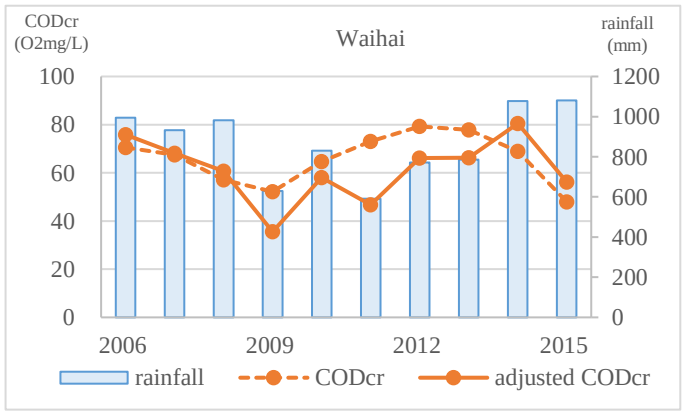
1.　Chemical Oxygen Demand (COD_{Mn})





2. Chemical Oxygen Demand (CODcr)





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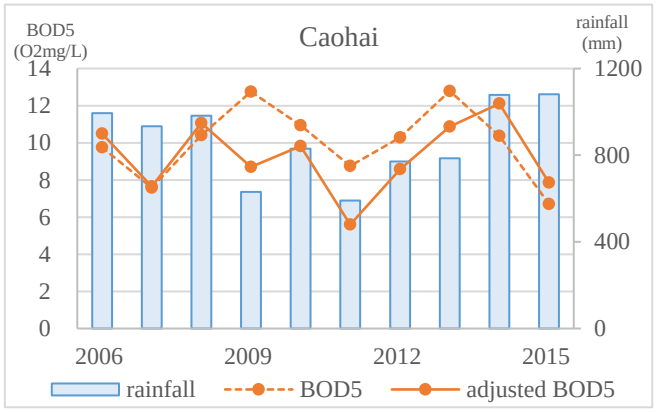
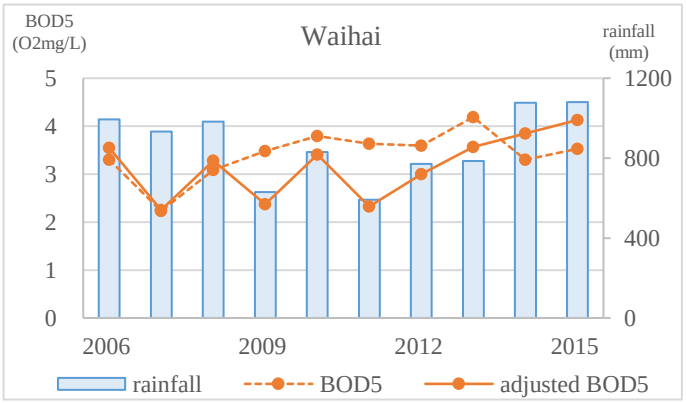
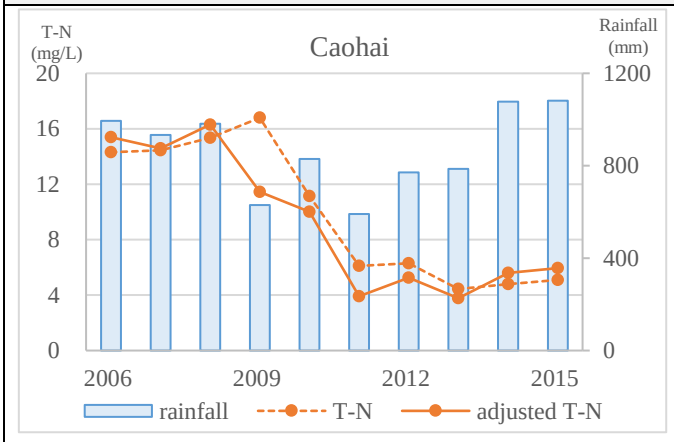
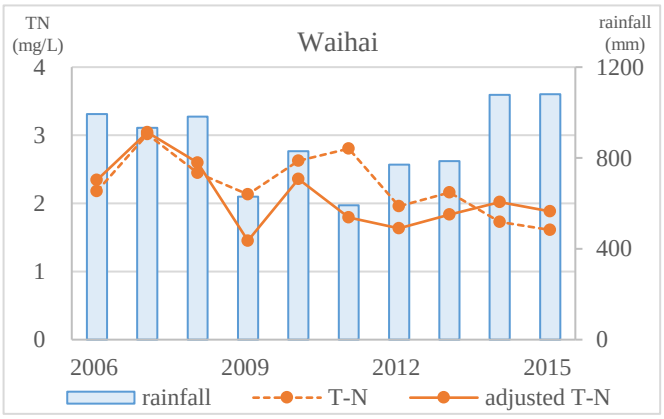


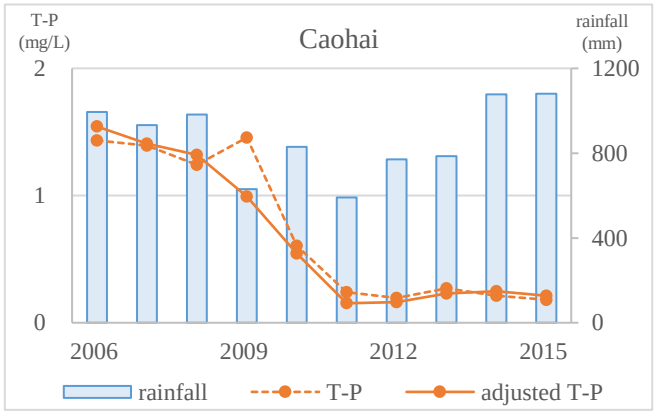


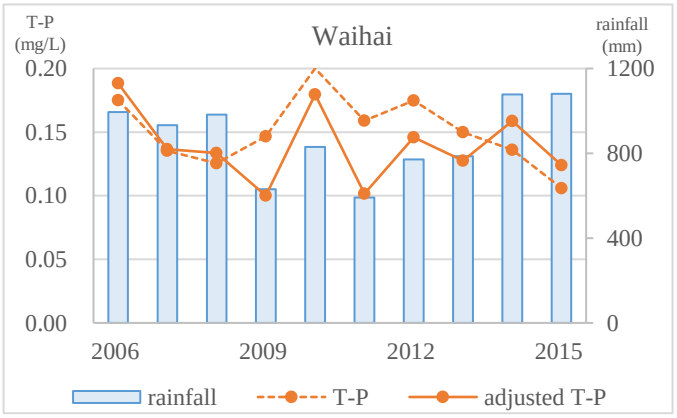
4. Total Nitrogen (T-N)



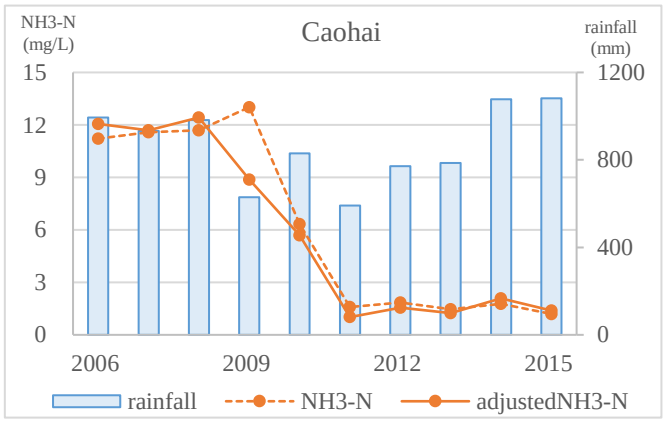


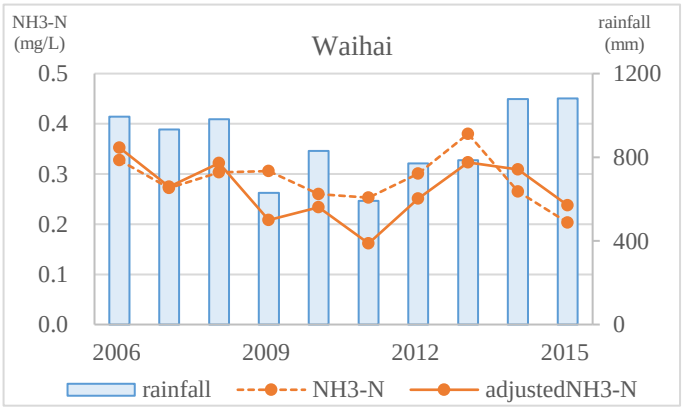
5. Total Phosphorus (T-P)





6. Ammoniac Nitrogen (NH3-N)





People's Republic of China

FY 2016 Ex-Post Evaluation of Japanese ODA Loan

"Shaanxi Water Environment Improvement Project (Xi'an City)"

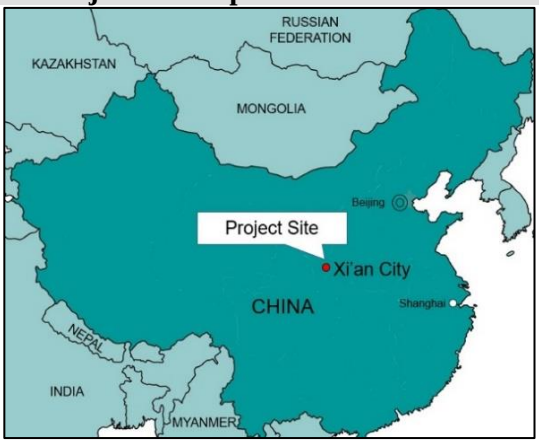
External Evaluator: Kenji Momota, IC Net Limited

0. Summary

This project was implemented in order to contribute to water environment improvement in Xi'an City, Shaanxi Province, including reduction in intracity river water pollution, clean water supply, and flood disaster reduction by constructing and improving sewage treatment plants, water pipe networks, and drainage canals in the city. The relevance of the project is high because of its consistency with the development policies and needs of China at the national, provincial, and municipal levels from the appraisal to the present time. The equipment improved in this project has been steadily operated, and main indicators have generally reached the planned targets, including the volume of water distributed and sewage treatment, reduction in pollutants, and the capacity of the drainage system. Judging from these facts, it can be evaluated that this project plays an effective role in reinforcing the functions of urban water supply and sewer services and flood control. As a result, this project has contributed to clean water supply, improvement on water pollution, and flood disaster reduction in Xi'an City. Thus, effectiveness and impact of the project are high. However, the efficiency of the project is fair because of its period and cost that exceeded the plan. With regard to the sustainability of this project, no significant problem is seen in institutional aspects and technical capability. Xi'an City has been able to stably cover financial expenditure on water, sewer, and drainage systems. This project is managed well as a public service with stable financial assistance and such assistance is expected to continue in the future. Thus, the sustainability of this project is high.

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

1. Project Description



Project Location

Biological Reaction Reservoirs at the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City

1.1 Background

In China, environmental pollution was accelerated by its industrialization and increasing population, while rapid economic growth was achieved after the 1980s. Although the country reinforced its environmental protection policies and produced a certain result after the middle of the 1990s, its effort for infrastructure improvement, including sewage treatment, could not catch up with industrialization and the population which increased even more than had been expected. Therefore, pollution remained at a serious level.

Xi'an City as an old capital of China and the capital of Shaanxi Province had a population of about seven million people as of 2002 and has rapidly grown owing to commercial and industrial development and urbanization. However, the city was left behind in improving water and sewer services: water supply service coverage ratio was 84% and the rate of sewage treated was no more than 37%. In the rainy season from July to September during which rainfalls were concentrated, sewage often overflowed from sewer pipes because of insufficient drainage system, and the urban area was flooded and damaged by the overflow of sewage. Under these circumstances, it was necessary to improve water environment, including sewage treatment plants, water pipe networks, and drainage canals, and this project was planned.

1.2 Project Outline

This project is intended to contribute to water environment improvement in Xi'an City, Shaanxi Province, including reduction in intracity river water pollution, clean water supply, and flood disaster reduction by improving sewage treatment plants, water pipe networks, and drainage canals.

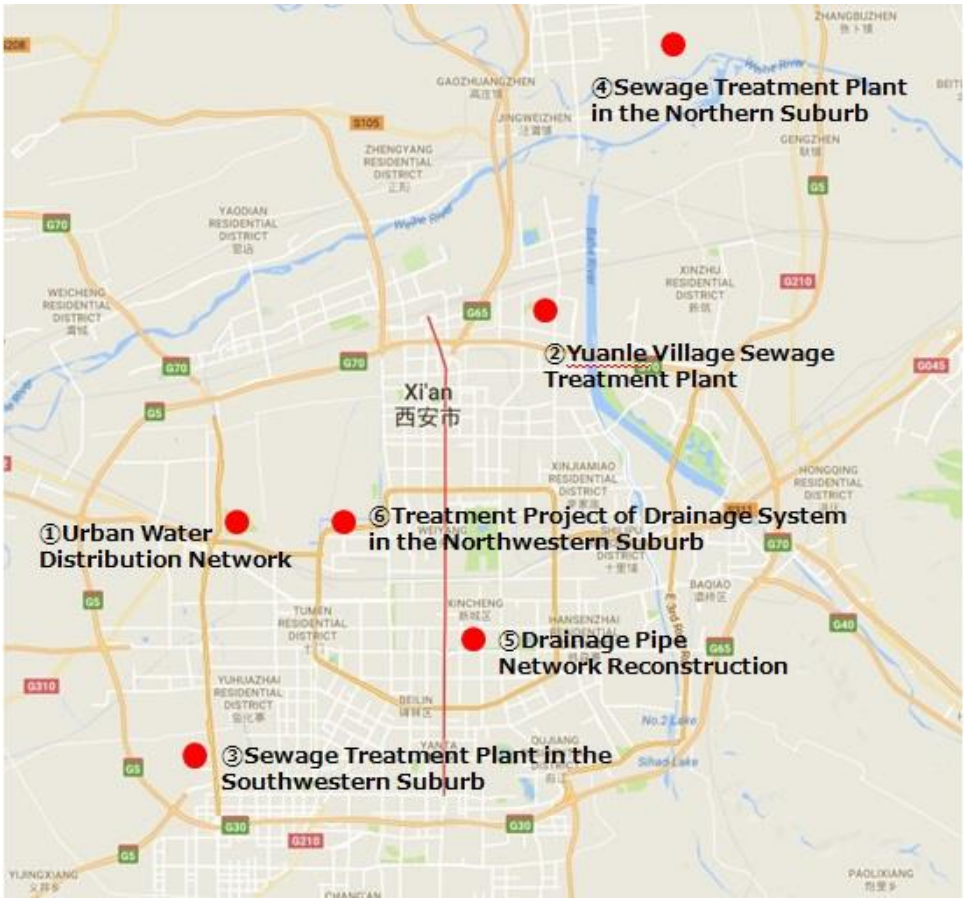


Figure 1: A Location Map of Xi'an City and Sub-projects under This Project

Loan Approved Amount/ Disbursed Amount	19,564 million yen / 18,444 million yen	
Exchange of Notes Date/ Loan Agreement Signing Date	March 2005 /March 2005	
Terms and Conditions	Interest Rate Repayment Period (Grace Period Procurement	1.5% 30 years 10 years) General untied
Borrower/ Executing Agencies	Shaanxi Provincial People's Government/ Xi'an Municipal People's Government	
Project Completion	October 2013	
Main Contractors (Over 1 billion yen)	・ China National General Machinery Engineering Corporation (China) ・ China Potevio Co. Ltd. (China) ・ Merit Technologies Inc. (China) ・ China National Machinery & Equipment Import & Export Corp. (China) ・ China National Precision Machinery Import & Export Corp. (China)	

	・ Hubei International Trade Investment & Development Co., Ltd. (China)/Xinxing Ductile Iron Pipes (Group) Co. (China) (JV)
Main Consultant	-
Feasibility Studies, etc.	F/S (Xi'an Municipal Design Research Institute, China Municipal Process Northwestern Design Research Institute, Xi'an Water Conservancy Construction & Observation Design Institute, Shaanxi Process Consultancy Bureau in August, 2003)
Related Projects	Xi'an Waterworks Improvement (1993) Xi'an City Environmental Improvement (2001) Shaanxi Water Environment Improvement (Shaanxi Province) (2005)

2. Outline of the Evaluation Study

2.1 External Evaluator

Kenji Momota, IC Net Limited

2.2 Duration of the Evaluation Study

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

Duration of the Study: July 2016 - October 2017

Duration of the Field Survey: October 16 - November 6, 2016; April 19 - 28, 2017

2.3 Constraints during the Evaluation Study

At the time of the appraisal, the planned effects of this project were to reduce intracity river water pollution, supply clean water, and reduce flood disasters. However, the direct effects of this project seem to have been the enhancement of the capacities for water supply, sewage treatment, and flood control. Reduction in intracity river water pollution, clean water supply, and flood disaster reduction were rated as impacts rippled by these effects. Because the quality of river water depends on factors other than sewerage improvement, it is difficult to evaluate the contribution of this project. Therefore, in this project evaluation, "enhancing the capacity for water supply," "enhancing the capacity for sewage treatment," and "enhancing the capacity for flood control" are evaluated as the effectiveness of this project, while "clean water supply," "contribution to reduction in intracity river water pollution," and "flood disaster reduction" are rated as impacts. However, grasping the present situation of the city on the whole was limited for lack of data on the quality of river water, which were not obtained from the Xi'an Municipal Environmental Protection Bureau.

3. Results of the Evaluation (Overall Rating: A[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Consistency with the Development Plan of China

(1) Consistency with the Development Plan at the Time of the Appraisal

1) Positioning of Water and Sewer Service Improvement in the Development Plan

In the *Tenth Five-Year Plan* (2001-2005), the Chinese government took it as a challenge to raise the capacity for urban water supply, increase the volume of water supply, and improve the quality of water by rehabilitating obsolete water facilities. As for sewage treatment, it was determined to aim at a treatment rate[3] of 45% in urban areas (60% in cities with 500,000 people and over). In addition, it is described that the specified value should be achieved in the quality of "three rivers and three lakes" and comprehensive measures to improve water quality should be taken in the upper course of the Yangtze River, the middle course of the Huang He, and the basin of the Songhua River. Thus, enhancing the capacity for sewage treatment covered by this project was identified as a development issue. With regard to water supply, objectives to be attained also included reinforcing the capacity for water supply and securing safe drinking water through the construction of new water facilities and the renewal of obsolete facilities in local cities, and saving water resources by reducing the rate of leakage.

In response to this, Shaanxi Province planned to increase sewage treatment plants in major cities, including Xi'an, in the *Tenth Five-Year Plan* (2001-2005) and set a target of 50% or more to be achieved in Xi'an City by 2005. For tap water, the province aimed at securing safe water as well as increasing water supply by promoting more use of surface water.

2) Positioning of Flood Control in the Development Plan

In the *Tenth Five-Year Plan* (2001-2005), priority in the development of flood control was given to the objectives of safety and security against floods and water disasters in major cities and regions and improvement in the system of flood prevention and disaster reduction. It was determined that the standard of protection against floods specified by the central government should be achieved in the middle and lower main streams of seven great rivers including the Yangtze River within the period of the plan. Thus, the enhancement of the flood control capacity covered by this project was identified as a development issue. Under the above-mentioned development policy of the central government, Shaanxi Province formulated the *Tenth Five-Year Plan* (2001-2005) and aimed to promote measures for preventing flooding of rivers and enhance the capacity for preventing flooding of important

[1] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[2] (3): High, (2): Fair, (1): Low
[3] Sewage treatment rate = Treated amount/ Total amount of sewage generated

rivers and cities by implementing dam repair and reinforcement projects.

(2) Consistency with the Development Plan at the Time of the Ex-Post Evaluation

1) Positioning of Water and Sewer Service Improvement in the Development Plan

In the *Twelfth Five-Year Plan* (2011-2015), "*The General Action Plan for Energy-saving and Emissions Reduction under the Twelfth Five-Year Plan* (2011-2015)" was formulated as a policy on environmental protection. In this action plan, a target of 85% was set for sewage treatment to be achieved by 2015. Efforts for environmental protection are also continuously strengthened by encouraging the use of recycled water.

In response to this, Shaanxi Province aimed at much more improvement in sewage treatment in the *Twelfth Five-Year Plan* (2011-2015). As objectives, it is described that the province will construct sewage treatment plants and aim at a treatment rate of 85% in middle-scale cities and a rate of 80% in prefectures by 2015.

2) Positioning of Flood Control in the Development Plan

In the *Eleventh Five-Year Plan* (2006-2010) of the national development plan, stated objectives were to secure safety against floods and water disasters in major cities and regions and reduce flood disasters. Subsequently, in the *Twelfth Five-Year Plan* (2011-2015), the country aimed to reinforce its flood prevention capability even more. To specify this objective, the *Nationwide Water Conservancy Development Plan* (2011-2015) was formulated. In this plan, three objectives were determined for large rivers and lakes, including the Huang He: 1. To improve large rivers and lakes and construct and reinforce regulating reservoirs; 2. To construct breakwaters and make general estuary improvement; and 3. To repair and reinforce dams and sluices which have a possibility of danger.

In response to this, Shaanxi Province announced the *Twelfth Five-Year Plan* (2011-2015) and showed more efforts to promote water security by improving waterworks prevalence and feed capacity and enhance the flood control capacity by implementing the river improvement plan for the whole of the Wei River on the full scale.

3.1.2 Consistency with the Development Needs of China

(1) Consistency with the Development Needs at the Time of the Appraisal

1) Needs for Water and Sewer Services

In those days, water supply service coverage ratio reached a credible level of 85% in Xi'an City. Nevertheless, underground water that did not meet the national standard for the quality of drinking water was used as a source of water in some regions, and there was a concern about an adverse effect of such water. Moreover, the city was late in securing safe

drinking water by improving water supply in its suburbs, which prevented urbanization and caused damage to health at the same time.

On the other hand, the sewage treatment rate[4] remained at a level of about 37% in Xi'an City at the time of the appraisal (2003) and much sewage was discharged without treatment. As a result, the quality of the Wei River flowing from east to west in Xi'an City was substantially below the national standard and exceeded Class V[5] of the national water quality environment standards in 2001. Subsequently, serious water pollution continued.

Thus, it was urgently needed to improve the capacities for water supply and sewage treatment, and this project was consistent with the imminent development needs.

2) Needs for Flood Control

In Xi'an City, roads were often flooded owing to the insufficiency of the drainage system in the rainy season (from July to September) during which rainfalls concentrated and often caused traffic suspension. This brought serious damage to both economic development and health/sanitation. In three waterways (Taiping River, Open Canal, and Xingfu Ditch), among others, which were constructed in the 1950s, the low capacity for flowing down and obsolescence raised a serious problem. They did not work well for urban drainage and flood discharge and caused a water disaster whenever there was a downpour. Thus, there were very strong needs for flood control measures.

(2) Consistency with the Development Needs at the Time of the Ex-Post Evaluation

1) Needs for Water and Sewer Services

The population of water distribution of Xi'an City in 2015 exceeded 4.5 million, which is a 1.9-fold increase compared with that at the time of the appraisal. As the increase is expected to continue following the development of the city in the future, it is necessary to continuously improve water infrastructure. Table 1 summarizes the situation of improvement in water and sewer infrastructure. One can see figures increasing year by year in every item. In this situation, Xi'an City plans to urbanize the suburbs and needs to improve the capacities for both water supply and sewage treatment even more. Although the quality of the above-

[4] Sewage treatment rate = Treated amount/ Total amount of sewage generated

[5] The water quality of rivers and lakes is classified into Classes I to V according to the surface water environment quality and quantity standards (GB3838-2002) as follows:
Class I: This is mainly applicable to water from the source of the river and national prior reserves. Class II: This is mainly applicable to a source of water for intensive drinking in the first-class reserves, valuable reserves for fish and egg-laying sites for fish and shrimps. Class III: This is mainly applicable to a source of water for intensive drinking in the second-class reserves and ordinary reserves for fish and swimming sites. Class IV: This is mainly applicable to industrial water districts, and recreational water districts which do not directly get in touch with human beings. Class V: This is mainly applicable to agricultural water and water areas necessary for general scenery.

mentioned Wei River improved from the level of Inferior Class V at the time of the appraisal, it remains in Class IV and still needs an appropriate measure for improvement.

Table 1: General Situation of Water and Sewer Services in Xi'an City

	2011	2013	2015
1. Tap Water			
Water Supply Capacity (10,000 m^3/day)	197.40	195.52	211.50
Water Supply Volume (10,000 m^3/year)	38,934	51,372	56,055
Population Served (10,000 people)	394.10	444.35	463.05
Distribution Pipe Network Length (km)	2,721.00	3,385.33	4,371.05
Water Supply Service Coverage Ratio (%)	100	100	100
2. Sewage			
Sewage Treatment Capacity (10,000 m^3/day)	111.60	153.10	200.60
Sewage Treatment Volume (10,000 m^3/year)	31,512	41,898	57,034
Sewage Pipe Network Length (km)	4,043.00	4,629.70	4,984.94
Sewage Treatment Rate (%)	85.90	90.72	91.85

Source: Statistical Almanac of Xi'an City

2) Needs for Flood Control

At the time of the ex-post evaluation, urban flood discharge and drainage have been facilitated more smoothly, damage by flooding has been mitigated, and urban safety against water disasters has been secured as a result of improving the drainage system. Meanwhile, improvement in the drainpipe network has recently advanced in Xi'an City, whereas drain is still merged with rainwater as conventional in the old urban area. There is also such a problem that the flowing-down capacity of the network is low because the diameter of drainpipe is narrow. The low prevalence and density of the drainpipe network causes overload for some areas. In the future, the city will need to continuously carry out an appropriate measure for flood control.

The following table shows the average annual rainfall and the maximum rainfall in Xi'an City. There is no large fluctuation in the average annual rainfall records after the start of this project in 2005. Since 2011, the maximum annual rainfall that may lead to a flood disaster has often been recorded in excess of the volume before the implementation of this project. Therefore, there is still a high possibility of flood occurrence, which requires the city to take an appropriate measure.

Table 2: Average and Maximum Annual Rainfalls in Xi'an City

Unit: mm

	2005	2006	2007	2008	2009	2010
Average Annual Rainfall	541.4	561.6	698.5	525.1	660.3	504.4
Maximum Annual Rainfall	722.8	600.9	734.9	626.4	846.9	735.4
	2011	2012	2013	2014	2015	
Average Annual Rainfall	423.6	426.7	423.9	660.3	551.6	
Maximum Annual Rainfall	948.0	532.2	535.2	792.4	810.0	
Reference: Usual Volume in Beijing					534.3	

Source: Responses to the questionnaire of the implementing agency

Under these circumstances, Xi'an City is now preparing[6] a policy to enhance the flood control capacity on the whole as a new effort and there is still a high need for flood control.

3.1.3 Consistency with Japan's ODA Policy

In the *Economic Cooperation Program for China* (2001) as an assistance policy of Japan toward China at the time of the appraisal, it is stated that emphasis will be placed on environmental and ecological conservation in China where environmental pollution and deterioration are serious. *The Medium-Term Strategy for Overseas Economic Cooperation Operations* (2002-2005) of JICA states clearly that there is the necessity for improving water supply and sewer services and tackling the problems of water resources among other priorities which include the reinforcement of the effort to reduce poverty, improvement in infrastructure for economic growth, the promotion of environmental conservation, and the prevention of pollution.

Moreover, in the *Country Assistance Strategy for China of JICA* formulated in 2002, support for the water environment and resources is stated. In particular, improving water and sewer services was emphasized as economic and social infrastructure for the activities of the private sector. As mentioned above, this project is highly consistent with Japan's ODA policy.

The implementation of this project is fully consistent with the development policy and needs of China and the ODA policy of Japan at the time of both the appraisal and the ex-post evaluation. Therefore, its relevance is high.

[6] According to the implementing agency of this project, they consider an idea of creating an infrastructure called "sponge city" which may enhance the flood control capacity. Specifically, it is a general infrastructure improvement plan which consists of a system whereby rainwater will be once reserved and then absorbed under the ground like a sponge and drained into a pipeline buried underground.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The planned and actual outputs in this project are as follows. Although the scope was partially changed and added, it can be evaluated that the planned outputs required for achieving the purpose of this project were generally realized as originally planned.

Table 3: Output: Plan and Actual Results

Sub-project	Plan (2005)	Actual (2016)
Urban Water Distribution Network	(1) Water pipe construction 260 km (2) Reservoirs, distribution plants, water quality measuring equipment, central control system improvement	**Partially changed** (1) Water pipe construction 215 km (2) Reservoirs, distribution plants, water quality measuring equipment, central control system improvement
Yuanle Village Sewage Treatment Plant	Treatment capacity 200,000 m^3/day	**As planned**
Sewage Treatment Plant Project (Southwest)	(1) Treatment capacity 80,000 m^3/day (2) Sewer pipe construction 60 km	**Almost as planned** (1) Treatment capacity 80,000 m^3/day (2) Sewer pipe construction[7] 58.6 km
Sewage Treatment Plant Project (North)	(1) Treatment capacity 100,000 m^3/day (2) Sewer pipe construction 160 km	**Almost as planned** (1) Treatment capacity 100,000 m^3/day (2) Sewer pipe construction 159.1 km
Drainage Pipe Network Reconstruction	Sewer pipe construction 231 km	**Almost as planned** Sewer pipe construction 230 km
Treatment Project of Drainage System	(1) Drainage system improvement 43 km (2) Tuanjie Reservoir waterway[8] improvement 12.675 km	**Partially changed and added** (1) Drainage system improvement 31.95 km (74% compared with the plan) (2) Tuanjie Reservoir waterway improvement 12.676 km (3) Addition: 3 bridges, 2 footbridges, retaining wall for bank protection, pump, sluice
Training	Training the employees of the implementing agency in Japan 70 people	**Almost as planned** Participating personnel: those of the implementing agency of this project and all the implementing agencies of the sub-projects Phase I: 20 people Phase II: 12 people Phase III: 25 people Phase IV: 20 people Total: 77 people (63 men and 14 women)

Source: The planned figures are data from JICA and the actual figures are responses to the questionnaire of the implementing agency.

[7] The Fourth Wastewater Treatment Plant deals with wastewater mainly in the urban area; and the Second Wastewater Treatment Plant, in the southern part. Except in a few areas, all the constructed sewage pipes are of a type that sends rainwater and wastewater to the treatment plant through separate pipes.

[8] This is based on the reference material provided by JICA

In improving the urban water system, the pipe network in the southwestern part of the city, being beyond the jurisdiction of the implementing agency of this project, was excluded from the target of improvement. Afterward, the change of the construction site following the change to urban development planning slightly prolonged the total length of the water pipe network within the jurisdiction compared with the plan. However, the total length of the constructed pipe network finally decreased in the whole of urban water system improvement. On the other hand, sewage treatment plants and sewer pipe networks were improved almost as planned.

In the Treatment Project of Drainage System (Northwest), the total length of the drainage system remained at 74% of the planned length. This is because some parts of the planned drainage system were integrated into the existing drainpipe network following the progress of urbanization and excluded from the coverage of this project. In addition, bridges and footbridges were also constructed for the sake of convenience of the local people and in order to secure the top width of the bank and resolve the problem of drainage in the local communities.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The project cost was planned to be 38,396 million yen (19,564 million yen in foreign currency and 18,832 million yen in local currency) at the time of the appraisal but was actually 45,073 million yen (18,324 million yen in foreign currency and 26,749 million yen in local currency), which is 117% of the plan.

The main reason for the increase in the project cost is an increase in the local currency due to soaring personnel and material costs. In particular, there were an increase of 173% in the cost of constructing the Yuanle Village sewage treatment plant and an increase of 150% in the cost of constructing the sewage treatment plant in the southwestern suburb of Xi'an City. According to the implementing agency of this project, the cost of obtaining sites also increased in addition to the increases in personnel and material costs. The increase was covered by the agency's own funds. On the other hand, with regard to the Comprehensive Treatment Project of Drainage System in the Northwestern Suburb of Xi'an City, the project cost was reduced to 65% of the plan by the cancellation of some outputs in this project.

3.2.2.2 Project Period

The project period planned at the time of the appraisal was from April 2005 to October 2011 (79 months)[9] but actually ran from April 2005 to October 2013 (103 months), which

[9] The completion of this project is defined as the completion of inspection in all sub-projects.

exceeded the planned period by 30%. This delay was mainly due to the delayed procedures for government approval and the change of the sites for constructing sewage treatment plants. The reason for a delay in each sub-project is as follows:

Table 4: Reasons for Delays in the Project Period

Sub-project	Reason for Delay
Urban Water Distribution Network	A delay of two years. It took much time to follow procedures for the approval of related agencies. Also, the construction of water pipes was delayed by a delay in the construction of urban roads carried out in parallel with this project.
Yuanle Village Sewage Treatment Plant	A delay of four years and ten months. Because of the change of the construction site forced by locational constraints, such as high-tension wires passing over the planned site for a treatment plant, the construction of the plant was delayed by two years and one month. In addition, technical problems occurred in the installation of a sludge disposal tank that was set up after the construction of the plant. It took more time than expected to complete the installation.
Sewage Treatment Plant Project (Southwest)	A delay of four years. The delay is due to the following two causes: (1) delay in the work to install pipes because of a delay in road construction by Xi'an Municipal People's Government outside this project; (2) This project had expected that it would need to follow only the procedures for approval by Xi'an City. However, it turned out to be necessary to follow the procedures for the approval of related agencies for procurement, as well as for inspection upon the completion of construction, at the municipal, provincial, and national levels. All of these procedures took more time than initially anticipated.
Sewage Treatment Plant Project (North)	A delay of one year and nine months. This was because the rapid progress of urbanization in suburbs required the change of the planned site for a treatment plant.
Drainage Pipe Network Reconstruction	A delay of one year. Although the construction of a pipe network was completed according to plan, completion inspection was delayed until the completion of roads constructed in parallel with this project.
Treatment Project of Drainage System	A delay of ten months. This was because the addition of such outputs as bridges, foot bridges, and sluices required additional coordination and field surveys.

Source: Responses to the questionnaire of the implementing agency.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

The financial internal rate of return (FIRR) of water and sewer services was calculated on the assumption that benefit would be income from water rates, cost would include the project cost and management, maintenance, and administration costs, and the project life would be 20 years.

The FIRR assumed at the time of the appraisal of the urban water service improvement project was 9.5% but became negative at the time of the ex-post evaluation. Water service is

managed as a public utility with financial investment from the municipal government and pricing of the service is kept at a low level. However, water supply cost has been increasing since the appraisal, and conceivably lowered profitability. Therefore, the service as a unit is managed in the red and compensated by a subsidy from the municipal government and non-operating income[10].

On the other hand, the FIRR of sewer service was estimated at 4.5% in the Yuanle Village Sewage Treatment Plant Project, 4.8% in the Sewage Treatment Plant Project in the Southwestern Suburb, and 4.1% in the Sewage Treatment Plant Project of Jinghe and Weibe Rivers Area in the Northern Suburb. In the field survey, however, the FIRR could not be calculated because financial data from each agency were not disclosed.

In the Drainage Pipe Network Reconstruction of Xi'an City and the Comprehensive Treatment Project of Drainage System in the Northwestern Suburb of Xi'an City, the economic internal rate of return (EIRR) was estimated at 14.7% (the former) and 14.4% (the latter) on the assumption that benefit would be a decrease in flood disasters, cost would include the project cost and management, maintenance, and administration costs, and the project life would be from 22 years to 50 years. However, the EIRR was not actually calculated because it was difficult to confirm detailed data required for benefit calculation after the completion of this project.

Both the cost and period of this project slightly exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness[11] (Rating: ③)

At the time of the appraisal, reduction in intracity river water pollution, clean water supply, and flood disaster reduction were expected as project effects. In this evaluation, first of all, as direct effects of the project, effects will be measured on the basis of direct outputs such as "enhancing the capacity for water supply," enhancing the capacity for sewage treatment," and "enhancing the capacity for flood control"; then, as a ripple effect, reduction in intracity river water pollution, clean water supply, and flood disaster reduction will be assessed.

3.3.1 Quantitative Effects (Operation and Effect Indicators)

(1) Improvement of water supply capacity

Table 5 shows the target value and actual performance of volume of water supply in the area targeted by this project, population served, and water supply service coverage ratio which have been set as operation and effect indicators. The target value set at the time of the

[10] This includes income from the connection of water pipes from the main pipe network to households and the construction of the main pipe network and commission fees for the relocation of the pipe network owing to underground railway and road construction and similar work.

[11] Rating is carried out by assessing not only the effectiveness but also the impact.

appraisal was achieved in terms of volume of water supply and population served; and, the rate of achievement against the target value is 120% for volume of water supply and 133% for population served. The rate of increase of volume of water supply was slightly lower than that of population served because of the improvement on water use efficiency as a result of such factors as recycling of industrial water, popularization of water-saving devices, and enhanced water-saving awareness among the population.

As, in parallel with this project, water pipe networks were also installed by domestic urban development projects, the installation of water pipe networks was completed in all areas under the jurisdiction of this implementing agency. Thus, the water supply service coverage ratio as of 2015, two years after the completion of the project, is 95.4%, which is very high; therefore, it can be said that the initial target, improvement of Xi'an City's water supply capacity, was achieved.

Table 5: Volume of Water Supply in the Area Targeted by This Project (Urban Area of Xi'an City), Population Served, and the Water Supply Service Coverage Ratio

		Baseline	Target	Actual		
		2003	2013	2013	2014	2015
		Appraisal year	2 years after completion	Completion year	1 year after completion	2 years after completion
Operation	Water Supply Volume (m^3/day)	696,000	1,323,000	1,492,159	1,493,589	1,591,000
	Population Served (person)	2,210,000	3,380,000	4,300,000	4,300,000	4,500,000
Effect	Water Supply Service Coverage Ratio (%) (Note 1)	84	92	91.2	91.2	95.4

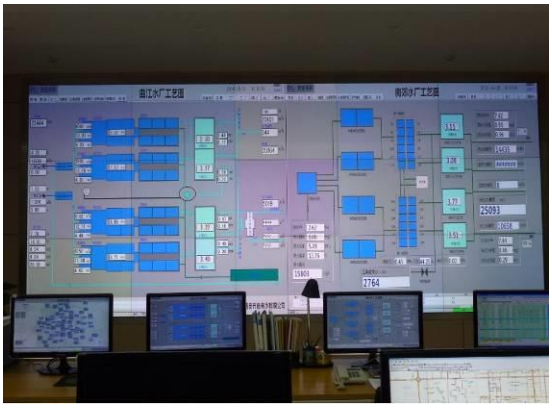
Source: The standard value and target value are based on the reference material provided by JICA; Actual performance is based on the answer of Xi'an Municipal Facility Administration Bureau to the questionnaire.
Note 1: Service coverage ratio = Population of water distribution / Total population of urban area of Xi'an City

The stability of water supply, including water pressure and water quality, is also improved. According to the interview conducted with the implementing agency of this project, the water pressure in the area targeted by this project is stable, as the average water pressure at the output of the water treatment plant is 0.5 MPa (Mega Pascal) and the water pressure in the area targeted by this project is 0.36 MPa.[12]. In addition, before this project was implemented, the water supply capacity was insufficient; for example, they had water rationing in summer time. After the completion of this project, there has been no such water rationing and water is supplied 24/7.

[12] The water pressure for general tap water in Japan is, depending on geological conditions, within the range of 0.05-1.0 MPa

With respect to water quality, as all major measurement values related to water quality meet national standards for drinking water[13], safe supply of water has been achieved.

Water Quality Measurement Equipment



Central Control Room

(2) Improvement of Sewage Treatment Capacity

The target set for improvement of sewage treatment facilities at the time of the appraisal was the one assumed for the treatment system of the city as a whole. For that reason, in the ex-post evaluation of this project, evaluation was carried out on the basis of the percentage this project accounts for in the indicators for the city as a whole. However, as no statistical data for the population served by sewer, which was set as an operational indicator, have been disclosed and the implementing agency has not been able to get hold of them either, we assessed the achievement of overall goal by amount of sewage being treated. In addition, with respect to conditions of water quality improvement of the discharge destination (Wei River), which was set as an effect indicator, it will be analyzed, as mentioned above, in the "Impact" section as reduction in intracity river water pollution.

The table below shows the target and actual performance of operational indicators. In this sewage improvement project, a total treatment capacity of 380,000 m^3/day was developed at three sewage treatment plants. This accounts for about 25% of Xi'an's total sewage treatment capacity at the time of completion of this project and approximately 20% of the actual amount of sewage being treated in the whole city, indicating that this is playing an important role in the sewage treatment system of Xi'an City which has a population of over 8 million. As the sewage treatment rate, together with various sewage treatment projects implemented in

[13] The reliability of water quality testing system of Xi'an City is high. Thanks to the introduction of water quality measurement equipment by this project, water quality measurement capability was also improved; for example, it became possible to measure all 106 test items specified by the National Drinking Water Standards. As 40 online automatic monitoring spots are up and running in the city currently, the measured data are transmitted to the central control room of the implementing agency in real-time, and they are checking the water quality to see if there is a problem as needed. In addition, the employees collect water samples from 120 measurement spots in the city to carry out a water quality test.

parallel with this project, has also improved by a large margin from 76% to 92%, it can be evaluated that this project has made an important contribution to the improvement of the sewage treatment capacity of Xi'an City.

Table 6: Xi'an City's Sewage Treatment Capacity

	Indicator (unit)	Baseline	Target	Actual		
		2003	2010	2013	2014	2015
		Appraisal year	2 years after completion	Completion year	1 year after completion	2 years after completion
Operation	Sewage treatment capacity (10,000 m^3/day)	/	/	153.1	153.1	200.6
	Ratio this project accounts for	/	/	24.8%	24.8%	18.9%
	Sewage treatment volume (10,000 m^3/year)	/	/	41,898	47,907	57,034
	Ratio this project accounts for	/	/	19.8%	19.0%	17.2%
	Sewage treatment rate (%) (Note 1)	37	76	90.72	92.71	91.85

Source: The standard value and target value are based on the reference material provided by JICA. Actual performance is based on Xi'an City's Statistical Yearbook and answers to the questionnaire by the implementing agency
Note 1: Sewage treatment rate = Treated amount / Total amount of sewage generated (Total amount of sewage generated in Xi'an City as a whole)

1) Operational status of respective sewage treatment plants developed by this project

To clarify the effects of this project, amount of sewage treated and the facility utilization rate for Xi'an Yuanle Village Sewage Treatment Plant, Sewage Treatment Plant in Southwestern Suburb of Xi'an City, and the Sewage Treatment Plant in Northern Suburb of Xi'an City are shown in the table below. The facility utilization rate after the completion of this project has increased steadily; and, the facility utilization rate as of 2015 has achieved 87.2% for Xi'an Yuanle Village Sewage Treatment Plant and 84.7% for the Sewage Treatment Plant in Southwestern Suburb of Xi'an City.

Table 7: Amount of Sewage Treated and the Facility Utilization Rate for Sewage Plants

		Actual (Note 1, 2)					
		2010	2011	2012	2013	2014	2015
Yuanle Village Sewage Treatment Plant (treatment capacity: 200,000 m^3/day)	Amount of sewage treated* (10,000 m^3/day)	n/a	13.34	13.77	15.76	17.20	17.44
	Facility utilization rate** (%)	n/a	66.70	68.85	78.80	86.00	87.20
Sewage Treatment Plant Project (Southwest) (treatment capacity: 80,000 m^3/day) (Note 3)	Amount of sewage treated (10,000 m^3/day)	3.30	3.90	4.60	4.70	5.60	6.80
	Facility utilization rate (%)	41.30	49.20	57.60	59.10	69.40	84.70
Sewage Treatment Plant Project (North) (treatment capacity: 100,000 m^3/day)	Amount of sewage treated (10,000 m^3/day)	0.50	0.70	0.95	2.25	2.17	2.61
	Facility utilization rate (%)	5.00	7.00	9.50	22.50	21.70	26.10

Source: Answer to the questionnaire by the implementing agency
*Average daily amount of sewage that a sewage treatment plant accepts and treats
** Average daily amount of sewage treated / treatment capacity
Note 1: The frame in bold line indicates the year of completion of the project
Note 2: Although the formal commencement of operation of Xi'an Yuanle Village Sewage Treatment Plant was in January 2011, as the commencement of operation of the sludge digestion tank was 2013, the year of completion for the project as a whole was 2013.
Note 3: Although the formal commencement of operation for the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City was May 2009, the completion year of the project as a whole including development of piping network is 2012.

On the other hand, although the amount of sewage treated by the Sewage Treatment Plant in the Northern Suburb of Xi'an City is on an upward trend after the completion of the project, the actual performance in 2015 stays at a low level being less than 30% of the design capacity. The reason for this, according to the implementing agency, is the fact that relocation of plants from urban areas to the area targeted for development was delayed owing to the delay of urban development. The Xi'an Municipal Government plans to complete relocation of plants by 2025[14]; it is estimated that the amount of sewage treated by the Sewage Treatment Plant of the Northern Suburb of Xi'an City will be approximately 98,000 m^3/day at that point. As the relocation of these plants has been decided in the development plan of the city and the probability of realization of relocation is high, it is expected that the amount of sewage treated by the sewage plant will also achieve the initial target over a medium term.

As discussed above, the utilization rate of the two treatment plants is over 80% and at a satisfactory level and the average utilization rate was 70% including the Sewage Treatment Plant of the Northern Suburb of Xi'an City, for which the amount of received sewage has not reached the planned value. It is highly likely that the utilization rate of the Sewage Treatment

[14] According to the Xi'an Weibei Industrial Zone Industrial Development Plan, all factories in the urban areas are to be relocated to industrial park zone in the future; and, it is anticipated that 23 companies will be relocated by 2020 and factories of 34 companies by 2025.

Plant of the Northern Suburb of Xi'an City will improve in the near future; therefore, it can be evaluated that the operational status is satisfactory as a whole.

2) Quality of water discharged from respective sewage treatment plants developed by this project

The table below shows the water quality at the discharge outlet of respective sewage treatment plants. With respect to the quality standard of discharged water, criteria for the National Standard Class 1A has been applied to the Xi'an Yuanle Village Sewage Teratment Plant and the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City since 2013 and to the Sewage Plant in the Northern Suburb of Xi'an City since 2015. With regard to main contaminants, the water quality after treatment has achieved all reduction results, exceeding National Standard Class 1A.

Table 8: Quality of Water Discharged from Respective Sewage Treatment Plants

Unit: mg/l

Sewage plant	Quality of discharged water (Note 1)	National Standard (Note 2)	Actual (Note 3)					
			2010	2011	2012	2013	2014	2015
Xi'an Yuanle Village Sewage Treatment Plant	COD concentration	50	-	27.7	24.1	22	21	19
	BOD concentration	10	-	10	9	7	7	7
	NH3-N concentration	5	-	1.63	0.91	0.93	0.973	1.054
Sewage Treatment Plant in the Southwestern Suburb	COD concentration	50	27	23	33	25	20	21
	BOD concentration	10	5	2	2	3	2	2
	NH3-N concentration	5	1.17	1.01	0.77	0.52	1.218	0.854
Sewage Treatment Plant in the Northern Suburb	COD concentration	50	-	-	47.6	33.9	29.0	35.2
	BOD concentration	10	-	-	14.6	15.5	13.9	8.6
	NH3-N concentration	5	-	-	4.40	1.21	0.79	0.70

Source: Answer to the questionnaire by the implementing agency
Note 1: COD means chemical oxygen demand; BOD, biochemical oxygen demand; and NH_3-N, ammonia nitrogen.
Note 2: The value of environmental standard set by the National Standard Class 1A
Note 3: The year marked by the bold line is the year the National Standard Class 1A was applied. Actual performance values show the values of respective sewage treatment plants since the official year of operation. The values for the National Standard and actual performance indicate the average values of respective concentration categories.

(3) Improvement of Flood Control Capacity

At the time of the appraisal, hours of flood damage occurrence per year due to levee crevasse or overflow were set as an operation and effect indicator. According to the Office of Flood Prevention and Management of the Xi'an Municipal People's Government, there has

been no flood damage since the completion of the project in Xi'an City. We can estimate the effects of this project based on the fact that the drainage canals developed by this project account for 80% of the drainage canals of Xi'an City as a whole and there has been no major flood damages so far although they had the same level of rainfalls as those that caused flood damages before the project. To analyze the effects in a more precise manner, with respect to the evaluation of improvement of flood control capacity, we carried out the evaluation on the basis of the assumed effects after verifying the developmental status of direct functions such as disposal capacity of the drainage canals. In concrete terms, we decided to use as the criteria whether the maximum rate of flow for the year over past years is within the flow capacity[15] and whether an appropriate manner of maintenance is being carried out.

The table below shows the flow capacity at the time of appraisal and that at the time of the ex-post evaluation. Before the implementation of the project, the flow capacity of the drainage canals by this project were 30 m^3/second for Taiping River, 30 m^3/second for Open Canal, and 15 m^3/second for Xingfu Ditch. It has been significant improvement, as these flow capacities have increased by as much as 3.2-fold on average.

Table 9: Flow Capacity and Rate of Flow of Respective Drainage Canals

Unit: m^3/second

Drainage	Flow capacity		Rate of flow					
	At the time of appraisal	At the time of evaluation	2010 Completion year	2011	2012	2013	2014	2015
Taiping River	30	92						
Maximum rate of flow for the year	-	-	61	83	54	66	51	69
Flow capacity - maximum rate of flow for the year	-	-	31	9	38	26	41	23
Open Canal	30	66						
Maximum rate of flow for the year	-	-	43	64	39	41	38	51
Flow capacity - maximum rate of flow for the year	-	-	23	2	27	25	28	15
Xingfu Ditch	15	69.7						
Maximum rate of flow for the year	-	-	36	65	37	43	35	54
Flow capacity - maximum rate of flow for the year	-	-	33.7	4.7	32.7	26.7	34.7	15.7

Source: Answer to the questionnaire by the implementing agency

[15] This means the maximum flow that can discharge the flood water safely.

In addition, the difference between the maximum rate of flow and flow capacity[16] of respective drainage canals is shown in the table above. According to the implementing agency, although they said that they were not able to get hold of the figures concerning the rate of flow before 2010, the year the three canals were completed, there had been flood damages such as levee crevasse, overflow, and flooding in the urban area before the implementation of the project every time they had heavy rain of 20-30 mm in a short span of time. As there has been no year in which the maximum rate of flow of the year exceeded the flow capacity after the completion of this project, we can see that discharged water is safely flowing down. In addition, as mentioned in "Relevance," considering that the precipitation in Xi'an City does not show any major change from the time of planning to the present, we were able to confirm that the risk of overflow and levee crevasse at the current standard weather conditions has been significantly reduced.

Those drainage canals developed by this project have been regularly maintained; as a result, it can be evaluated that they are maintaining the planned capability, such as capacity of flow. (See "3.5 Sustainability" for details)

On the basis of the above, although there is limitation in carrying out quantitative analysis of reduction of flood damage, as drainage canals with expected flood control capacities have been developed, it can be evaluated that the effect of drainage canal development is high.

3.3.2 Qualitative Effects (Other Effects)

As effects of recycling, the reuse of treated water and reuse of sludge were expected. Respective statuses are discussed as follows:

(1) Reuse of Treated Water

As the use of treated water is still at the discussion stage, reuse of treated water has not yet been put into practice. They say that the Sewage Treatment Plant in the Northern Suburb of Xi'an City uses the treated water for watering roadside trees, etc.; and, at this stage, they are considering the future use of treated water in the sewage plant by preparing a concrete technical plan.

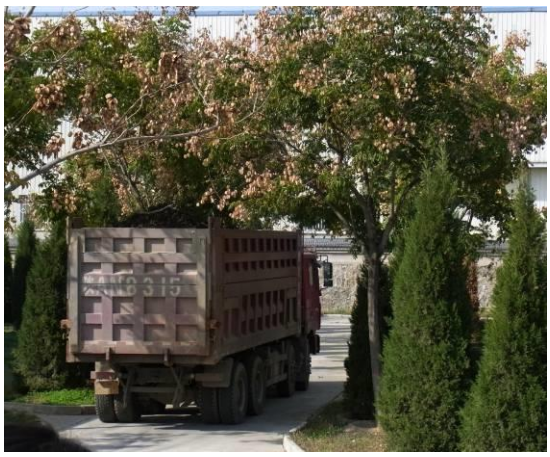
(2) Reuse of Sludge

The sludge generated after the treatment of sewage goes through primary treatment[17] at the treatment plant and then all of it is outsourced to go through regeneration process as

[16] If the maximum rate of flow for the year is less than flow capacity, it means that river water is flowing safely without overflow.

[17] This treatment decreases the water content rate of sludge to 75 to 80% by using a centrifugal separator.

planned; it is mainly reused as tiles, bricks, or compost. In addition, with regard to the Sewage Treatment Plant Project in Yuanle Village, as a sludge digestion tank was installed by this project, the environment to use sludge to generate methane gas as a source of heat supply in the treatment plant has been developed. However, at the time of study, operation of the digestion tank had been suspended since the end of 2015 and we were told that the cause of trouble was still under investigation.



A Truck Carrying Sludge

Sludge Digestion Tank at the Xi'an Yuanle Village Sewage Treatment Plant

3.4 Impacts

3.4.1 Intended Impacts

The expected impact of this project is improvement of Xi'an City's water environment as a whole through supply of clean water, reduction of water pollution, and reduction of flood disaster. We will now analyze the role this project played in relation to this impact.

(1) Supply of Clean Water

1) Water quality

As mentioned in "Effectiveness and Impact," after development of a water pipe network was carried out through this project, the water supply service coverage ratio has achieved almost 100%. As the water quality satisfies national drinking water quality standards with respect to all test items, it has been proven appropriate as tap water. In addition, as the range of water supply was expanded as a result of development of the water pipe network, all wells were closed in Xi'an City after the implementation of this project.

2) Reduction of waterborne diseases

Although it is difficult to prove direct causal relationship between reduction of

waterborne diseases and effects of this project, cases of water related diseases are on a downward trend up until now in Xi'an City. If one compares the number of hepatitis patients and that of diarrhea patients between 2015 and 2005, it has been confirmed that, despite increased population, the number of hepatitis patients was reduced by 9,519 cases and that of diarrhea patients by 5,890 cases. Although it is not possible to prove the causal relationship in a clear-cut manner, there is a possibility that realization of supply of clean water led to the reduction of waterborne diseases such as diarrhea.

(2) Reduction of water pollution

As this project is positioned as a part of the city planning of Xi'an City and the treatment capacity of those sewage treatment plants that were developed by this project accounts for approximately 25% that of Xi'an's total urban areas, it can be evaluated that the project played an important role in controlling the sources of water contamination of the rivers in the City. Before the implementation of this project, as there were no sewage treatment plants in suburban areas, most sewage had been discharged into the river untreated. It can be said that this project has contributed to the reduction in intracity river water pollution in both urban areas and suburbs of Xi'an City by developing an independent sewage treatment system in the suburban area; i.e., the construction of a sewage treatment plant in the southwestern suburb as well as the one in the northern suburb.

The table below shows an estimated amount of contaminants removed by the implementation of this project and the ratio of the removed contaminants in comparison to the total in Xi'an City as a whole. The ratio of contaminants reduced by this project is as much as 29.1% for COD and 22.4% for NH_3-N on average between 2010 and 2015. As the treatment capacity of the sewage treatment plants developed by this project accounts for 20% of the total in Xi'an City as a whole, it can be said that this project showed more than expected results in reducing the contaminants in the city as a whole.

Table 10: Amount of Contaminants Reduced

	2010	2011	Actual 2012	(Note) 2013 The year this project was completed	2014	2015
COD reduction amount by this project (tons/year)	4,964	32,941	39,013	42,049	41,882	44,993
NH_3-N reduction amount by this project (tons/year)	462	2,421	2,654	2,954	3,065	3,397
Ratio this project accounts for in Xi'an City's COD reduction amount	4.4%	38.9%	48.0%	44.8%	29.3%	23.4%
Ratio this project accounts for in Xi'an City's NH_3-N reduction amount	5.4%	26.6%	33.5%	31.4%	22.9%	18.4%

Source: The reduction amount by this project is based on the answer to the questionnaire by the implementing agency; and, the reduction amount of Xi'an City is based on Xi'an Statistical Yearbook.
Note: The year all three sewage treatment projects were completed is 2013.

Sewage to be treated by this project had been discharged into the tributaries of the Wei River untreated. According to Shaanxi Provincial People's Government Environmental Protection Bureau, the water quality of Wei River, which had been class "V minus" in 2006, was improved to be assessed as class "IV" in 2015. As factors other than this project can have significant impact on the water quality of the river, it is difficult to prove causal relationship with this project; however, considering that the share of the sewage treatment capacity of this project accounts for a high percentage of the total sewage capacity of the city, it is conceivable that this project is making a certain contribution to the improvement of water quality of the Wei River.

(3) Reduction of flood disaster

There are, roughly speaking, five drainage systems in Xi'an City; and, as the rain water and sewage coming from most of the urban areas of the Xi'an City except for the eastern area are collected by the Zao River, Open Canal, and Xingfu Ditch, these three drainage systems accounts for more than 80% of the drainage systems of Xi'an City's urban area.[18] As the Taiping River (a tributary of the Zao River), Open Canal, and Xingfu Ditch play an extremely important role in the flood control system of the city as a whole, it can be said that the development of drainage systems implemented by this project has also made a significant

[18] The rain water and sewage of southern area, western area, and northwestern area are all discharged into the Zao River and Taiping River, and then into the Wei River; and, the rain water and sewage of old urban areas are mainly discharged into the Tuanjie Dam and then through Open Canal to the Wei River; and, the rain water and sewage of northeastern area are discharged into the Wei River through Xingfu Ditch.

impact in terms of reduction of flood disaster in the city as a whole.

In addition, as flooding risk in the urban area was significantly reduced thanks to the development of the drainage pipe network implemented in the urban area, the flood defense standard (recurrence cycle) of the drainage pipe network in Xi'an's urban area was improved from once in one and half years (once in three years for certain areas) at the time of the appraisal in 2005 to once in five years by the time of the ex-post evaluation.

As stated in "Relevance," there has been no significant change with respect to the precipitation in Xi'an City since the time of planning; and, the current risk of occurrence of flood disaster is the same as at the time of planning. On the other hand, as drainage capacity has improved significantly after the development of drainage systems and drainage pipe network and there has been no flood disaster such as overflow, it can be evaluated that this project made a certain impact on reduction of flood disaster in Xi'an City as a whole.

With respect to the reduction of flood disaster, partly because there has been no serious damage since the completion of the project, we were unable to confirm a direct impact as actual performance. For that reason, with the cooperation of the implementing agency, we conducted a beneficiary survey[19] with 120 residents who were randomly selected from households' lists in areas that reportedly had been affected by frequent flood disaster, to confirm the effects of Treatment Project of Drainage System.

According to the beneficiary survey, all 70 respondents who said that they had experienced flood disaster in the past answered that they had experienced flood disaster on their farmland. On the other hand, with respect to flood disasters after 2010, all 120 respondents targeted for the survey answered that there had been significant improvement in relation to flooding of farmland; and 98% of them answered that it had been significant improvement in relation to other damages such as mudslide or landslide as well as flooding over/under the floor level. Further, 94% of them answered that fear of flood disaster was mitigated.

In addition, out of the 120 respondents targeted for the survey, 116 or 97% of them answered that environmental conditions of nearby rivers have improved; and, the other four respondents answered that they have generally improved. In fact, with respect to environmental improvement of rivers, the implementing agency also expressed a view that, although considerable foul odor was generated before the treatment project of drainage system, at present, odor has been mitigated and water quality has also been improved so much so that even fish came to live there.

[19] The survey was conducted on 120 residents of Sha He Tan Village, located in the basin of the Zao River and Taiping River, in the urban area of the city, and Ba Xing Tan Village, located in the lower basin, where flood disasters frequently occur, (60 residents in Sha He Tan Village and another 60 in Ba Xing Tan Village) by the door-to-door survey method. Respondents were: 77% of male and 23% of female; 20-29 of age (3%), 30-39 of age (23%), 40-49 of age (38%), 50-59 of age (33%), and 60-69 of age (1%).

3.4.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

In the environmental assessment carried out before the implementation of the project, there was no report of serious negative impact on or risk to the natural environment or ecological system in relation to any sub-projects. Moreover, with regard to the outputs that were added in a few sub-projects, it was confirmed that they had no particular impact on the environment.

At the time of the implementation of the project, as a measure against the odor from sewage treatment plants, such measures as installation of deodorizing facilities in the building were taken.

In addition, at the Sewage Treatment Plant in the Southwestern Suburb of Xi'an City, observation points were established at the boundary of the plant premises, and odor index has been monitored to confirm that it is less than the index specified by the national standard. In addition, with respect to all sewage treatment plants, a strict monitoring system has been developed where the Xi'an Municipal Environmental Protection Bureau is constantly monitoring the quality of the discharged water online and carrying out regular on-site inspections. As they have not heard of complaints from local residents either, no particular impact on the natural environment has been recognized.

(2) Land Acquisition and Resettlement

1) Resettlement

As had been planned, there has been no relocation of residents in relation to all sub-projects.

2) Land Acquisition

The actual area of land acquired is 223.8 ha, which is 118% of the plan. Looking at the area of acquired land for respective sub-projects, it increased to 136% of the plan for Yuanle Village Sewage Treatment Plant and 143% for Sewage Treatment Plant Project of Jinghe and Weihe Rivers Area in the Northern Suburb of Xi'an City. This is because, in Yuanle Village, on top of the land for the plant, acquisition of extra lands for roads and green spaces became necessary. In addition, the area of land to be acquired increased because there was a case where it was necessary to acquire a whole village[20]; the location for the construction of the sewage treatment plant in the Northern Suburb was changed and the new location included a part of the village. With respect to the urban water distribution network, the area of acquired land increased significantly by 700% compared to the plan because the installation routes of

[20] The land to acquire was someone's property but not a place of residence. No one lived there.

water supply pipe were revised in consideration of city planning. With respect to all sub-projects for which acquisition of land was required, the acquisition was carried out smoothly, as required procedures such as briefing in advance and compensation were followed according to the domestic law.

(3) Other Positive and Negative Impacts

With regard to the Tuanjie Reservoir water way developed by this project, before the implementation of the project, it was in an unsanitary environment with piled up rubbish and overflowing sewage; however, thanks to this project, a drainage system was developed, water environment became clean, and landscape was improved. As a result, the water way became a place of recreation and is now designated as one of the national waterside scenic spots. In addition, thanks to the efforts of the municipal government, Xi'an Water Conservation Museum was established, as an auxiliary facility for the purpose of enhancing ecological protection awareness, which is open to the residents in the vicinity free of charge. With respect to this, the implementing agency says that this is resulting in improvement of awareness of the nearby residents concerning protection of the environment.

Further, after the training course in Japan in this project, Xi'an City and Kyoto City have reached an agreement to continually engage in exchange and collaboration in the area of protection of water environment with improvement of combined-type sewage pipe as a theme of future cooperation. Based on this, grass-root technical cooperation projects were implemented in Xi'an City in 2010 and 2011 taking advantage of support from Kyoto City, and cooperation between the two cities has been strengthened.

As stated above, since its objectives were generally achieved in accordance with the plan by implementation of this project, its effectiveness and impact are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

According to the plan at the time of the appraisal, Xi'an Municipal Infrastructure Construction Investment & Management Co., Ltd. (hereafter "Management Co., Ltd.") is to carry out, commissioned by the Xi'an Municipal Government, overall supervision of procurement and construction of this project in an integrated fashion. For managing the sub-projects, implementing agencies such as Municipal Facility Administration Bureau and Sewage Treatment Co., Ltd. were assigned. Although at the time of project evaluation, the name Management Co., Ltd. was changed to Xi'an Urban Infrastructure Investment Group Co., Ltd., as the main personnel in charge of this project have not been replaced since the time of appraisal and are continually engaging in communication and coordination with

implementing agencies, etc., and supervision of subordinate organizations which carry out operation and maintenance of the operation, there have been no major changes to the substantive operation of this project. With respect to the implementing agencies of sub-projects, although there have been partial changes from the time of planning in terms of organizational framework, names, and so on, there have been no changes to the substance as a state enterprise in relation to respective agencies. In addition, as respective agencies responded that they have no privatization plan, it is likely that there will be no major changes to the current framework in the medium and long terms.

3.5.2 Technical Aspects of Operation and Maintenance

(1) Technical Level Concerning Management and Maintenance

With respect to both water and sewage systems, the implementing agencies responsible for sub-projects have previously been involved in the operation of respective facilities; and while doing that, they have employed human resources who have certain skills and experience on a preferential basis. As the water and sewage facilities including ODA loan projects are, both in terms of employed technologies and facilities, standard ones that have been used in China before, it is considered that the engineers who have been working for Xi'an's water and sewage program have accumulated a certain degree of operational knowhow and experience and have ability required for operation and maintenance. In addition, an education and training system for engineers and other employees has also been developed; and, after taking the course or practical training concerning operation and management or machine operations, etc., they are required to sit for a written examination or technical test, and they are obliged to acquire a qualification in machine operation and so on. As a framework to maintain technical capability has been developed, for example, they proactively engage in transfer of skills among engineers, we cannot see any problem in regard to their technical capability in general.

(2) Status of the Development of an Operation and Maintenance Manual

In the field study, we conducted a survey with sub-project implementing agencies from such perspectives as follows: Protocol of operation and management, the manner in which troubles are dealt with, and whether the report and communication system has been established as a rule, commonly accepted, and practiced as an organization. As a result, we were able to confirm that operational and maintenance manuals have been developed in all sub-projects, and common perception among employees regarding their work and level of understanding of the manual are also generally high.

On the basis of above, as technical capability of the employees required for operation and

maintenance has been ensured and the operational and maintenance environment for maintenance has also been established, it is considered that technical aspects for the sustainability of project effects are high.

3.5.3 Financial Aspects of Operation and Maintenance

The table below shows the annual budget of the Xi'an Municipal Government and expenditure for water-related sectors as well as its percentage of the whole budget. As indicated in "Relevance," we can see that development of water and sewage infrastructure has been carried out in a continual manner even after the commencement of the project and investment has continued to be put into the sector as a priority area in municipal development. The water and sewage program, being a public utility service, assumes financial management to be supported by subsidies and assistance from the government; and, considering the growth and scale of Xi'an Municipal Government's spending and stable expenditure for water related areas, it can be judged that a major problem is unlikely to emerge at this point.

Table 11: Fiscal Budget of the Xi'an Municipal Government

Unit: 10,000 yuan

	2011	2012	2013	2014	2015
General account	4,945,750	5,974,937	7,298,119	8,195,366	9,172,400
Agriculture, forestry, and water related expenditure (Note 1)	387,899	451,053	499,357	487,646	566,231
Percentage	7.8%	7.5%	6.8%	6.0%	6.2%

Source: Xi'an Statistical Yearbook
Note 1: As we could not confirm any financial data specific to the water sector, we used the data above as a substitute.

The financial statuses of respective programs are shown below.

(1) Water Supply System Development Program

Although water rate income alone cannot cover operation and maintenance costs, resulting in a slight deficit, the fee collection rate is high at 99.5%-99.8% as shown in Table 12. In addition, with regard to the income and expenditure of the most recent two years, the total turnover including water and sewage rate income and non-operating income exceeds the total expenditure, indicating that income and expenditure are well balanced.

Table 12: Income and Rate Collection Rate

Unit: 10,000 yuan

	2014	2015
Total income	94,951	99,110
Water supply fee income	80,460	88,831
Non-operating income	14,491	10,279
Total expenditure (Note 1)	82,958	91,978
Rate collection	99.65%	99.68%

Source: Answer to the questionnaire by the implementing agency
Note 1: Including operation and maintenance costs, labor costs, etc.

As the water supply program is implemented as a public utility service, if operation and maintenance budget is not sufficient, it would be supplemented by a subsidy from the municipal government; however, at the time of the ex-post evaluation, we did not see any need for that. When one also takes into account the stable financial status of the municipal government, there is no problem in financial aspects for the sustainability in this area.

(2) Sewage Treatment Plant/Drainage Pipe Network/Drainage System Development Program

Sewage treatment, flood mitigation, and urban drainage programs are not operated as an individual profit-making business, as they are operated and maintained by a state enterprise under the jurisdiction of the municipal government. For this reason, we were given an answer that there are no detailed financial data at the implementing agency or they cannot be disclosed. From what we know from the interviews with sub-project implementing agencies, the following has been confirmed with regard to the financial management situation.

1) The water service company collects from users a sewage fee in combination with a water charge, and the collection rate is stable.
2) The sewage treatment plant in the Southwest area receives no revenue from a sewage fee. It receives all of its maintenance cost as a subsidy from the high-tech zone.
3) The sewage treatment plants of Yuanle Village and the Northern Suburb use a sewage fee and a subsidy for the maintenance fee.

Based on the above, with regard to the financial status of all the sewage projects, it can be evaluated that a stable financial base is being maintained as, although direct profitability of the sewage projects is low, operation and maintenance are carried out assuming there is financial assistance from the municipal government.

On the basis of the above, revenue source for expenditures required for operation and maintenance of the water, sewage, and drainage program is warranted in the finances of the

Xi'an Municipal Government and, according to the interviews with implementing agencies, it is expected that assistance from the government will continue for the time being; therefore, we see no problems with sustainability of operational and maintenance expenditures.

3.5.4 Current Status of Operation and Maintenance

The status of operation and maintenance of each sub-project after the completion of the project is good and facilities and equipment are operating without a problem. With respect to spare parts and engineers and support for maintenance, we were able to confirm that it is possible to procure or deal with all of them domestically and there have been no particular problems. In field study, we conducted an interview with the employees in charge of the operation and management, and confirmed that the following operation and maintenance are carried out in relation to respective facilities:

Table 13: Status of Operation and Maintenance

Sub-project	Status of Operation and Maintenance
Urban Water Distribution Network	Regular patrolling, monitoring, and routine inspection are carried out in relation to chlorine treatment facilities, hoisting equipment, pumps, electrical facilities, clean water reservoirs, and so on. The Water Quality Management Department was established inside Xi'an Municipal Facility Administration Bureau which is in charge of operation and maintenance; they measure 106 items of water quality as prescribed by the national standard and the results of the test are recorded as water quality measurement report which is reported to supervisory organizations including Xi'an Municipal Environmental Protection Bureau.
Yuanle Village Sewage Treatment Plant	Operation and maintenance are carried out under common perception with respect to daily operation, including maintenance, testing, and monitoring where everyone understands what has been set out to do. At the treatment plant, they take water samples every day to measure the water quality. Part of the operation, the sludge digestion tank installed by this project, has been suspended since the end of 2015; however, that does not cause any problem in relation to the operation of the sewage plant itself.
Sewage Treatment Plant Project (Southwest)	Operation and maintenance are carried out on the basis of patrol inspection and routine maintenance once a month. To verify whether the treatment method is appropriate, they send a sample of treated water to a state-designated organization to measure the water quality.
Sewage Treatment Plant Project (North)	Patrolling monitor is carried out to check operational status of the facilities, measurement of water quality of the meters, etc. on a regular basis. Measurement of the quality of treated water is carried out every day at the laboratory in the sewage plant, and the results of the measurement are cross-checked with the data of online measurement equipment to see if there is any malfunction of equipment.
Drainage Pipe Network Reconstruction	They carry out patrol inspection of each pipe once a month, reinforcement of pipes before flood/snow season, and sampling of rainwater once a month.
Treatment Project of Drainage System	They carry out daily cleaning, replacement of parts by patrol inspection of facilities once a month, and regular water quality checking. At the time of the year when heavy rain tends to occur, they check the weather forecast in advance, increase the frequency of the patrol inspection, and monitor water levels, etc. When they spot abnormalities or overflow while patrolling, they send a rescue team to the site and issue an evacuation order to the residents around the site.

Source: Answer to the questionnaire by the implementing agency and answer to the hearing at the time of local study

On the basis of above, the related policy and institutional aspects of this project in terms of organizational aspects, technical aspects, and financial aspects are all without problems; therefore, the sustainability of project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was implemented in order to contribute to water environment improvement in Xi'an City, Shaanxi Province, including reduction in intracity river water pollution, clean water supply, and flood disaster reduction by improving sewage treatment plants, water pipe networks, and drainage canals in the city. The relevance of the project is high because of its consistency with the development policies and needs of China at the national, provincial, and municipal levels in the period from the appraisal to the present time. The equipment improved in the sub-project has been steadily operated, and main indicators have generally reached the planned targets, including the volume of sewage treatment and reduction in pollutants. Judging from these facts, it can be evaluated that this project plays an effective role in reinforcing the functions of urban water and sewer services and flood control. As a result, this project has contributed to water quality improvement, clean water supply, and flood disaster reduction in Xi'an City. Thus, effectiveness and impact of the project are high. However, the efficiency of the project was fair because of its period and cost that exceeded the plan. With regard to the sustainability of this project, no significant problem is seen in organizational capacity and technical aspect. Xi'an City has stably continued financial expenditure on water, sewer, and drainage systems. This project is managed well as a public service with stable financial assistance. Accordingly, such assistance is expected to continue in the future. Thus, the sustainability of this project is high.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

With respect to the sludge digestion tank at the Xi'an Yuanle Village Sewage Treatment Plant, as it has been some time since the suspension of operation at the end of 2015, it is feared that the equipment could deteriorate. It is necessary to urgently consider measures, in addition to coordination toward functional recovery, to prevent deterioration; for example, request for short-term support of the manufacturer for the purpose of maintaining the condition of the equipment, and a short-to-middle term work plan toward operation.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Improvement of the effects of development by expansion of related policies taking advantage of Japanese ODA loan.

As mentioned in “Effectiveness and Impact,” in the Comprehensive Treatment Project of Drainage System in the Northwestern Suburb of Xi’an City, a sub-project of this project, Xi’an Water Conservation Museum was established, taking advantage of the drainage system constructed by the project (Tuanjie Reservoir Water Way) through the efforts of the municipal government. It is considered that the Xi’an Municipal Government had an intention to enhance the effects of an ODA loan project; for example, realization of continuous introduction of related environmental improvement projects on its own funds, by taking advantage of the output of Japanese ODA loan as a catalyst for related measures toward environmental improvement and demonstrating its effects.

To enhance the effects of implementation of an ODA loan project, it is desirable to ensure that we consider a scenario which would further enhance the effects of development by proposing a project which is highly consistent with the infrastructure, comprehensive urban development plans, and policies, etc., of the implementing agency of the project, positioning the effects of the ODA loan project in such way that it facilitates a subsequent development plan, and letting it lead to further input.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
(1) Project Outputs Urban Water Distribution Network	(1) Installation of water pipe: 260 km (2) Development of water pond, water distribution station, water quality measurement equipment, and central control system	(1) Installation of water pipe: 215 km (2) As planned
Yuanle Village Sewage Treatment Plant	Treatment capacity: 200,000 m^3/day	As planned
Sewage Treatment Plant Project (Southwest)	(1) Treatment capacity: 80,000 m^3/day (2) Installation of sewage pipe: 60 km	(1) As planned (2) Installation of sewage pipe: 58.6 m
Sewage Treatment Plant Project (North)	(1) Treatment capacity: 100,000 m^3/day (2) Installation of sewage pipe: 160 km	(1) As planned (2) Installation of sewage pipe: 159.1 km
Drainage Pipe Network Reconstruction	Installation of sewage pipe: 231 km	Installation of sewage pipe: 230 km
Treatment Project of Drainage System	(1) Development of drainage system: 43 km (2) Development of Tuanjie Reservoir water way: 12.675 km	(1) Development of drainage system: 31.95 km (2) Development of Tuanjie Reservoir water way: 12.676 km (3) Installation of three bridges, two pedestrian overpasses, floodwall, pump, and water gate
Training program	Training program in Japan for the employees of implementing agency: 70 people	Personnel of the implementing agency of this project and all the implementing agencies of the sub-projects:77 people in total (63 men and 14 women)
(2) Project Period	April 2005 - October 2011 (79 months)	April 2005 - October 2013 (103 months)
(3) Project Cost Amount Paid in Foreign Currency	19,564 million yen	18,324 million yen
Amount Paid in Local Currency	18,832 million yen (1,416 million yuan)	26,749 million yen (1,916 million yuan)
Total	38,396 million yen	45,073 million yen
ODA Loan Portion	19,564 million yen	18,324 million yen
Exchange Rate	1 yuan=13.3 yen (As of September 2004)	1 yuan=13.96 yen (Average between 2005 and 2013)
(4) Final Disbursement	July 2014	

People's Republic of China

FY2016 Ex-Post Evaluation of Japanese ODA Loan

"Baotou Atmospheric Environment Improvement Project"

External Evaluator: Kenji Momota, IC Net Limited

0. Summary

This project was carried out in Baotou City, an industrial center of the Inner Mongolia Autonomous Region, to construct a natural gas pipeline that should help facilitate energy transition from coal to natural gas and reduce emissions of air pollutants with a view to improving the air quality of the city and raising the levels of living and environmental standards of the people there.

This project is highly relevant, as it agreed with the air pollution countermeasures specified in the development plan from the time of appraisal to the present at all of the nation, autonomous region, and city levels. Efficiency of the project is fair, as both the project cost and project period exceeded the plan. However, influences of the delay were controlled with some measures adopted to improve efficiency, such as replacement of materials and machines with better ones and enhanced efficiency of construction work. The gas supply has achieved the target set for the amount of gas to be supplied. Since the completion of the project, stable distribution has been maintained, with no supply interruption. That has enabled the city to replace coal, an inefficient combustion source, and reduce pollutants in the atmosphere. In 2015, the concentration of pollutants in the air was controlled below the national criteria on more than 90% of the days. As people living there notice improvements in air and living environments, effectiveness and impact of the project are high. The organization operating this project has achieved stability in all of organizational, technical, and financial aspects. Therefore, sustainability of the project effects is high.

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

1. Project Description

Project Location

Western Gate Station

1.1 Background

Amid rapid economic growth from the 1980s, China experienced increasingly serious pollution caused by industrialization and population growth. Especially from the late 1990s, the Chinese government adopted stricter environmental protection policies, achieving some degree of success. Nonetheless, pollution remained quite serious. In China, the atmosphere was seriously polluted, mainly with sulfur oxides (SO_X), total suspended particles (TSP), and nitrogen oxides (NO_X), generated when burning coal, the main energy source for the country. In 2003, the amount of SO_2 emitted by China was more than 30 times the amount of SO_X emitted by Japan. Acid rain was also observed in cities around China.

The site of this project, Baotou City of the Inner Mongolia Autonomous Region, suffered from serious air pollution caused mainly by SO_2 and soot and dust emitted from heavy industry that was achieving rapid growth and ordinary households using coal and coal boilers in winter for heating. Concentrations of SO_2 and TSP were higher than the national air quality standards applicable to residential areas, or Class 2. Among the 113 air-polluted cities designated by the national government for environmental protection, Baotou was ranked 13th from the bottom. Pollution was so serious that improving the air quality was a challenge the city had to address urgently.

Against such backdrops, this project was planned to reduce coal consumption in Baotou and improve the quality of the heavily polluted atmosphere.

1.2 Project Outline

This project was designed to construct a natural gas pipeline in Baotou City, one of the major industrial centers of the Inner Mongolia Autonomous Region, and help facilitate energy transition from coal to natural gas and reduce emissions of air pollutants with a view to improving the air quality of the city and raising the level of living and environmental standards of the people there.

Loan Approved Amount / Disbursed Amount	8,469 million yen / 8,451 million yen	
Exchange of Notes Date / Loan Agreement Signing Date	March 2005 / March 2005	
Terms and Conditions	Interest rate: Repayment: (Grace period: Financing conditions	0.75% 40 years 10 years) General untied
Borrower / Executing Agencies	The Government of the People's Republic of China / Inner-Mongolia Autonomous Regional People's Government	
Project Completion	August 2014	

Main Contractors (Over 100 million yen)	・China Peak Development Limited (PRC) ・Merit Technologies Inc. (Beijing) (PRC) / Beijing Zhonghui United Environmental Engineering Co., Ltd. (PRC) ・Beijing Bril Sanyou Technology Development Co., Ltd. (PRC)
Main Consultant (Over 100 million yen)	-
Feasibility Studies, etc.	F/S: Produced by the North China Municipal Engineering Design Institute of China in August 2004 (Approved by the Development and Reform Commission, Inner Mongolia Autonomous Region Government in September 2004) Special Assistance for Project Formation (SAPROF): Baotou Atmospheric Environment Improvement Project, Inner Mongolia Autonomous Region (January 2005)
Related Projects	・Hohhot and Baotou Environmental Improvement Project (December 1996) ・Hohhot and Baotou Environmental Improvement Project (2) (September 1997)

2. Outline of the Evaluation Study

2.1 External Evaluator

Kenji Momota, IC Net Limited

2.2 Duration of the Evaluation Study

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

Duration of the Study: July 2016–October 2017

Duration of the Field Study: October 18–26, 2016; April 20–22, 2017

3. Results of the Evaluation (Overall Rating: A[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Consistency with the Development Plan of China

(1) Consistency with the Policy at the Time of the Appraisal

1) Consistency with the Policy at the National Level

Despite the success of the Chinese Government in achieving the target it had set in the "9th Five-Year Plan for Environmental Protection" (1996–2000) for the environment sector, the amount of pollutants emitted remained huge, and urban areas continued to suffer from a serious level of air pollution. Having seen that, the

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

[2] ③: High, ②: Fair, ①: Low

government drew up the “10th Five-Year Plan for Environmental Protection” (2001–2005), setting a target of reducing emissions of major pollutants (SO_2, TSP, etc.) by 10% from the 2000-level. Especially in the field of air environment, it aimed at reducing SO_2 emissions by 20% from the 2000-level in the “SO_2 Pollution Control Zones” and “Acid Rain Control Zones”, and mentioned promotion of natural gas and other clean energies as another target.

2) Consistency with the Policy at the Autonomous Region and City Levels

In line with the central government's “10th Five-Year Plan for Environmental Protection”, the “Inner Mongolia Autonomous Region Government 10th Five-Year Plan” (2001–2005), set a target of reducing emissions of major pollutants, such as SO_2 and soot and dust, by 10% by 2005 from the 2000 level, and especially in the “SO_2 Control Zones” and “Acid Rain Control Zones”, cutting SO_2 emissions by 21% from the 2000 level. The “Inner Mongolia Autonomous Region Government 10th Five-Year Plan” (2001–2005) also mentioned a program for promoting transition to clean energies.

In the “Baotou City Environmental Protection of the 10th Five-Year Plan” (2001–2005), the municipal government set specific targets. The Baotou City Environmental Protection Regulation stated, “Designation as Area of No Highly Polluting Fuel” and “Obligatory Transition to Natural Gas or Other Clean Energies” among its principles.

(2) Consistency with the Development Policy at the Time of Ex-Post Evaluation

1) Consistency with the Policy at the National Level

The “12th Five-Year National Development Plan” (2011–2015) set the target of reducing emissions of CO_2, SO_2, and NOx per unit of GDP by 17%, 8%, and 10%, respectively. The “12th Five-Year National Plan for Environmental Protection” (2011–2015), which embody the target, placed greater emphasis on efforts to control air pollution, setting a target of increasing the share of non-fossil fuels in primary energy consumption to 11.4% by 2015, mainly through restraining coal use.

2) Consistency with the Policy at the Autonomous Region and City Level

In “Inner Mongolia Autonomous Region Government 12th Five-Year Plan” (2011–2015), the natural gas is ranked as a major energy source to replace coal, presenting some initiatives for promotion. Specifically, the plan stated that construction of natural gas pipelines should be accelerated to raise the penetration ratio of natural gas to at least 85%, that construction of pipelines for transporting energy-related

products should be enhanced to raise the capacity to distribute such products out of the region, and that, with the aim of improving the quality of atmospheric environments in the region and urban areas, 70% of the major cities in the autonomous region should achieve Class-2 national standards for air quality on at least 292 days. Baotou City also produced "Baotou City Environmental Protection of the 12th Five-Year Plan" (2011–2015), setting a higher target of satisfying the Class-2 national air quality standards on at least 329 days. In 2014, for helping remove coal-fired boilers and facilitating projects for introducing more energy-efficient central heating systems or gas-fired units to concentrate supply sources into one, the city government implemented policy programs for encouraging removal of small-size boilers in the city.[3]

As described above, since the planning of this project, a series of initiatives with higher targets have been introduced at each of the nation, autonomous region, and city levels for addressing air pollution problems. This project, as a program for implementing the initiatives in a more specific manner, is evaluated to be highly relevant.

3.1.2 Consistency with the Development Needs of China

(1) Consistency with the Development Needs at the Time of the Appraisal

Along with economic growth, the Inner Mongolia Autonomous Region saw an about 81% increase in energy consumption between 1995 and 2003. Coal accounted for about 94% of the consumption, causing a serious air pollution problem. The Autonomous Region emitted about 810,000 tons/year of SO_2 (2003), more than the total SO_X emissions of Japan, about 630,000 tons/year (2000). It suffered from serious air pollution caused mainly by SO_2 and soot and dust emitted from heavy industry that was achieving rapid growth and ordinary households using coal and coal boilers in winter for heating. In Baotou City, concentrations of air pollutants persistently stayed above the Class 2 national air quality standards.

[3] "The Notice Regarding the Guidelines for Removal of Heat-supply Coal-fired Boilers and Networking in Major Urban Areas in Baotou City" and "The Notice Regarding Guidelines for Improvement of Commercial and Residential Coal-fired Boilers in control zones, Baotou City" (both in 2014)

Table 1: Concentrations of Air Pollutants in Baotou City

Indicator	1999	2000	2001	2002	2003	Class 2 National Standards
SO_2 (mg/m^3)	0.085	0.084	0.072	0.084	0.081	0.06
TSP (mg/m^3)	0.439	0.382	0.394	0.378 Note 1	-	0.20
PM_{10} (mg/m^3)	-	-	-	0.237 Note 2	0.277	0.1

Source: Documents provided by JICA (Data provided by Environmental Protection Bureau of Baotou Municipal People's Government)
Note 1: From January to May
Note 2: From June to December. Since June 2002, TSP was replaced by PM_{10} as indicator.

(2) Consistency with the Development Needs at the Time of the Ex-Post Evaluation

The table below shows emissions of air pollutants in the Inner Mongolia Autonomous Region. Even on a downward trend, amounts of pollutants emitted into the air are larger than the total emissions of Japan in 2000. Improving the air quality is a critical challenge to address.

Table 1: Air Pollutant Emissions in the Inner Mongolia Autonomous Region

Indicator	2004	2007	2010	2015
SO_2 (10,000 tons)	-	145.6	139.4	123.1
NOx (10,000 tons)	-	-	-	113.9
TSP (10,000 tons)	-	-	-	-

Source: Responses to questionnaires of Baotou Fuel and Gas Co., Ltd.

The table below presents numbers of factories in heavy industry in Baotou City during the same period. From 2009, factories increased by almost 40%, indicating continued growth of combustion sources causing air pollution.

Table 3: Numbers of Heavy Industry Factories in Baotou City

Indicator	2009	2010	2011	2012	2013	2014	2015
No. of heavy industry factories	12,318	15,998	16,502	16,467	16,640	16,640	-

Source: Responses to questionnaires of Baotou Fuel and Gas Co., Ltd. (Data of Statistics Bureau of Baotou City)
Note: No data were available for a period between 2004 and 2008.

In Baotou City, air pollutants have been at a serious level since the time of the appraisal for this project. To date, heavy industry and urban areas, both of which are major polluters, have been growing. In such circumstances, transforming the energy

structure, from coal combustion to cleaner natural gas, is a critical policy. Thus, it is fair to say that initiatives for transition of energy sources including this project answered a major need of Baotou City for improving the air quality.

3.1.3 Consistency with Japan's ODA Policy

At the time of appraisal for this project, the "Economic Cooperation Program for China" (announced in October 2001) referred to "Cooperation towards resolving environmental and other global issues" and "improvement of living standards and social development in the inland regions" as priority areas. The "Medium-Term Strategy for Overseas Economic Cooperation Operations", announced April 1, 2002, and the "Country Assistance Strategy for China" (FY2004) both placed emphasis on "environmental conservation", and mentioned "support for environmental improvement and pollution prevention" as one of the priority issues. Both policies pointed out environmental improvement as an important issue, a fact demonstrating great consistency with this project.

In light of the above, this project has been highly relevant to China's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The table below compares the plan for this project and its actual results. The main parts of the project have been completed almost as planned.

Table 4: Output: Plan and Actual Results

Output	Plan (2004)	Actual At time of project completion (2014) Parenthesized: Percentages to plan
1) Western Gate Station (1 set)	New construction	Almost as planned Location changed to Baotou suburbs.
2) Donghe Gate Station (1 set)	Expansion	As planned
3) Kundulun District Regulating Station (high/medium pressure) (1 set)	New construction	As planned
4) Development Zone Regulating Station (high/medium pressure) (1 set)	Expansion	As planned
5) Special-purpose Regulating Station (high/ medium pressure) (1 set)	New construction: 8 factories Expansion: 3 factories	New construction: 6 factories (75%) Expansion: As planned
6) Regulating Boxes (medium/low pressure)	New construction: 120 units	New construction: 110 units (91%)
7) Gas Pipeline	・High Pressure New construction: 54 km ・Medium Pressure New construction: 52 km Replacement: 270 km ・Low Pressure Replacement: 441 km	・High Pressure: 48.66 km (90%) ・Medium Pressure: 325.24 km (101%) ・Low Pressure: 468.18 km (106%)
8) Gas equipment: Nozzle adjustment & inner pipe repair	Coverage: 147,000 households	As planned
9) SCADA System	1 set	As planned
10) Valves	・High Pressure: 15 units ・Medium Pressure: 100 units ・Low Pressure: 300 units	As planned
11) Training Program in Japan for Air Quality Improvement	3 groups (12 persons in total)	1 group (5 persons) (41%)

Source: Documents provided by JICA; Actual values are based on responses to questionnaires of Baotou Fuel and Gas Co., Ltd.

For outputs in which any change was made, major factors that led to the change are shown in the table below.

Table 5: Factors Causing Any Change in Outputs

Output	Changes
1) Western Gate Station	The "12th Five-Year Plan of Baotou City" changed the route of the pipeline to be laid from the Ordos Gas Field. Accordingly, the location of the station was changed from the southern part of Baotou City to its southwestern suburbs to secure safe and stable supply of natural gas.
5) Special-purpose Regulating Station	Fewer new factories are constructed after bankruptcies and relocations.
6) Regulating Boxes	The number of units was changed to 110 at the time of detailed design for the optimal arrangement planning.
7) Gas Pipeline	[Total length] In the latter half of the "11th Five-Year Plan of Baotou City", the city planning was modified with some changes to the routes of new roads. As a result, the total length of the gas pipeline system was altered. [Material] Cast-iron pipes, adopted at the time of the planning, were replaced by steel and polyethylene (PE) pipes, as they are better in pressure resistance.
11) Training Program in Japan for Air Quality Improvement	[Fewer sessions & participants] After a long delay in the bidding, the main construction work had to catch up with the schedule. For that, more people were deployed for the work, and fewer could afford to visit Japan to attend training seminars. [Implementation period] A training seminar was held in April 2010. Originally, three sessions were scheduled for September 2006, September 2007, and September 2008.

Source: Responses to questionnaires of Baotou Fuel and Gas Co., Ltd.

Despite several changes to the outputs mostly due to some modification in the city planning, no significant alternation was made that might give any impact on achievement of the purposes of the project or its efficiency. The project produced most of the outputs as originally planned.

Regulating Box Installed in a Housing Complex

SCADA System
(At Baotou Fuel and Gas Co., Ltd. Headquarters)

3.2.2 Project Inputs

3.2.2.1 Project Cost

At the time of appraisal, the project cost was estimated at 13,962 million yen [foreign currency: 8,469 million yen; local currency: 5,493 million yen]. The actual cost turned out to be 15,351 million yen [foreign currency: 8,443 million yen (100% to the plan); local currency: 6,908 million yen (126% to the plan)] (ODA loan in foreign currency: 8,443 million yen). The actual cost was about 10% higher than that of appraisal (110% to the plan).

Table 6: Project Cost: Breakdown

Unit: million yen

Item	Foreign Currency		Local Currency		Total	
	Total	ODA Loan	Total	ODA Loan	Total	ODA Loan
Materials & Equipment / Civil Engineering	8,435 (8,058)	8,435 (8,058)	3,532 (1,564)	0	11,967 (9,622)	8,435 (8,058)
Training	8 (26)	8 (26)	0 (4)	0	8 (30)	8 (26)
Others (General Administration)	0	0	2,679 (105)	0	2,679 (105)	0
Land Acquisition	0	0	697 (1,335)	0	697 (1,335)	0
Price Escalation	0 (385)	0	0 (32)	0	0 (417)	0
Physical Contingency	0	0	0 (574)	0	0 (574)	0
Interest during Construction	0	0	0 (1,879)	0	0 (1,879)	0
Total	8,443 (8,469)	8,443 (8,469)	6,908 (5,493)	0	15,351 (13,962)	8,443 (8,469)

Note1: Figures in parentheses are estimations.
Note2: The expense for the item “Interest during Construction” is included in the item of “Others”.

The table below shows the factors that pushed up the cost. Among them, increases in material costs for gas pipes and personnel expenses during the project period were significant. Especially, labor costs continued rising between 2004 and 2013, at an annual average of over 15%[4]. Another factor with significant impact was changes in the currency exchange rate. Between 2009, (the year of first disbursement was made from the ODA loan), and 2014, the value of yuan fluctuated by about 4.8 yen from the bottom to the peak.

[4] China's Minimum Wage System and New Trends Toward Development (Ma Xiaoli, 2015), The 12th Northeast Asia Labour Forum: Recent Trends in Wages and Minimum Wage System, *JILPT Foreign Labour Information, February 2015*, The Japan Institute for Labour Policy and Training

Table 7: Factors of Changes in the Project Cost

Factors Pushing Up the Cost	Factors Pushing Down the Cost
• Higher labor costs amid pay increases in China nationwide (Average annual increase of 15.13% between 2004 and 2013 in the Inner Mongolia Autonomous Region).	• Changes in pipeline materials (cast iron to steel & PE).
• Fluctuations in exchange rate that reduced value of funds raised in a foreign currency when converted into CNY (up to about 4.8 JPY/CNY between 2009, and 2014).	• Fewer visits to Japan for a training program
• Higher material cost for PE pipes adopted in the latter half of the project period (Low-pressure: up 18%; Medium: up 21%).	

Despite several factors that pushed up the project cost as mentioned above, a change in pipeline materials, from cast iron to steel, delivered a cost reduction of about 328 million yen. Instead of steel ones, more cost-efficient PE pipes[5] were adopted for the latter half of the project. The savings made up for changes in the specifications stated above, such as the extended total length of the pipeline and purchases of pipes of larger diameter.

As a result, the project cost was indeed higher than planned with increases in labor and other expenses, but cost reductions achieved by changes of materials, and efficient redistribution of the savings helped control the total cost increase to 10%.

3.2.2.2 Project Period

At the time of appraisal, the project was planned to start in March 2005 (signing of Loan Agreement) and end in December 2013 (for 106 months). The actual project period started in March 2005 (signing of Loan Agreement) and ended in August 2014, finished with some delay in 114 months, or 108% of the plan. Periods at each stage of the project are shown below in detail.

[5] However, the material cost for PE pipes also increased by some 20% from around 2013. Because of the higher pipe prices, together with the extension of the total length of the pipeline and other factors, the project was finished with a 10% increase in the total cost, as stated in this report.

Table 8: Project Period: Plan and Actual Results

		Plan			
Main Construction		Detailed Designing	Bidding	Construction	Commissioning
	Started in:	August 2004	April 2005	September 2006	September 2007
	Ended in:	February 2005	August 2006	December 2013	December 2013
Training		Session	1st	2nd	3rd
		Held in	September 2006	September 2007	September 2008
		Actual			
Main Construction		Detailed Designing	Bidding	Construction	Commissioning
	Started in:	August 2004	December 2007	July 2007	December 2013
	Ended in:	January 2006	November 2011	December 2013	August 2014
Training		Session	1st	2nd	3rd
		Held in	April 2010	—	—

Source: Responses to questionnaires of Baotou Fuel and Gas Co., Ltd.
Note: A project is regarded as completed when inspection is finished.

The project period was prolonged because, after the signing of the ODA loan agreement, it took a longer time for the Finance Bureau of Baotou City and Baotou Fuel and Gas Co., Ltd., to complete procedures for the sub-loan between them.

As a result, the bidding got started much later with a 32-month delay. The implementing agency, Baotou Fuel and Gas Co., Ltd., took actions stated below to shorten the construction period, successfully limiting the overall delay of the project period to about eight months.

- Cooperation with municipal agencies: The city government, having ranked this project as critical for its environmental policy, provided support by, for instance, allowing simplified procedures at the construction stage. At the preparation stage before the bidding, the Baotou Fuel and Gas Co., Ltd. wasted no time working with relevant government agencies to make arrangements about, for instance, when construction work for building roads should be carried out as the timing would influence when to do work for laying pipes, deciding what solution to apply to problems they could foresee.

- Construction methodology and planning for higher efficiency: Parts of the construction work financed by funds raised in the local currency got started first.

Once having laid pipes at some sections, they started inspection and gas supply there, while carrying out construction work at other sections at a time, pursuing a more efficient construction methodology. The second and third sessions of the training program in Japan were canceled, giving priority to deployment of personnel to the construction work.

Despite a large delay in internal procedures taken necessary for the government to conclude the contract, Baotou Fuel and Gas Co., Ltd., planned and implemented practical tasks for the project in a more efficient manner to minimize the delay in the entire process.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

Financial Internal Rate of Return (FIRR)

At the time of the appraisal, the financial internal rate of return (FIRR) of the project was computed at 3.65%. A calculation performed again for this evaluation has shown that the FIRR is 25.15%. Just as done at the time of the appraisal, the calculation was carried out with revenues from gas rates counted as a benefit, and initial capital expenditure, together with annual maintenance expenses, included in cost, to find a rate of return during the project life, or 20 years. The larger FIRR is attributable mainly to higher unit prices of gas than at the time of the appraisal, present conditions expected to guarantee a stable growth of supplies at almost 7%, and a larger share of factories, businesses, and other commercial users that pay a higher unit rate than ordinary households. Together with financial sustainability mentioned below, the actual FIRR suggests stable conditions in the operation of gas business.

Both the project cost and the project period exceeded the plan. Therefore, the efficiency of the project is fair.

3.3 Effectiveness[6] (Rating:③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

We compare the effects expected from conversion of energy from coal to natural gas with the actual performance.

(1) Operational Status of the Gas Supply Business

The total amount of gas supply came close to achieving the target volume in 2015 stage; then, the amount of supply as of October 2016 increased to as much as

[6] Sub-rating for Effectiveness is to be put with consideration of Impact.

586,887,300 m^3/year, achieving the targeted volume.

With respect to the gas supply on the basis of sales volume for various uses, the gas supply structure has greatly changed from the one at the time of the appraisal, as the current main demand is for industrial use such as heavy industrial plants, which accounts for 77% of the total. One of the background factors why the gas supply for industrial use has increased, as stated in "Relevance," is that the Baotou Municipal People's Government came out with a policy to promote conversion to natural gas and concrete measures were put in place. It can be evaluated that the rapid conversion was particularly accelerated by the enforcement of city regulation, established in 2014, concerning removal of coal boilers in business establishments and the realization of stable natural gas supply environment by this project. On the other hand, the supply volume for general household use, which was initially anticipated to be the largest source of demand, has been less than half of the target volume. This is because, while the supply volume for general household use has decreased by a great margin, the gas supply for industrial use has increased significantly. The probable reason for the decline of the supply volume for general household use is improvement in the efficiency of gas supply thanks to building of a concentrated heat supply system in the urban area.

Table 9: Operational Status of Gas Supply

Indicator	Baseline 2004 Appraisal Year	Target 2014 1 Year After Completion	Actual value 2015 1 Year After Completion
Amount of natural gas supply (10,000 m^3/year)	730.0	58,067.0	57,919.0
Sales volume of natural gas for general household (residence) use (10^4m^3/year)	0.0	14,488.0	6,330.0
Sales volume of natural gas for industrial use (10^4m^3/year)	730.0	33,923.0	44,345.0
Sales volume of natural gas for public facilities, etc. (10^4m^3/year)	0.0	9,656.0	7,243.0
Number of beneficiaries (users) of natural gas (number of contracts)[Note 1]	-	-	441,500 households
Prevalence rate of natural gas (%)	6.9	91.6	96.0

Source: Standard values are based on the documents provided by JICA; Actual values are based on responses to questionnaires of Baotou Fuel and Gas Co., Ltd.

Note1: The number of beneficiaries (users) of natural gas (number of contracts) indicates the number of households using gas for general residential houses.

Baotou Fuel and Gas Co., Ltd., buys natural gas from Changqing gas field located at Ordos, which is located to the south of Baotou City in the same Inner Mongolia Autonomous Region and known as a resource city with abundant reserves of mineral resources. According to Baotou Fuel and Gas Co., Ltd., the supply environment is stable, as the gas supply has never been interrupted since the start of operation. In addition, as the gas pipeline network was developed as a loop structure, it can cope with temporary interruption of gas supply as a result of accident in the pipeline network, etc., and there has been no interruption since the start of operation.

(2) Amount of Pollutant Emission Reduction

In this section, we analyze to what extent the emission of pollutants from conventional energy sources such as coal was reduced by conversion to natural gas. In concrete terms, we estimated the amount of pollutant emission when the equivalent amount of coal was used to that of natural gas in 2015 ($57,919 \times 10^4$ m^3) and worked out the difference.[7] The table below summarizes the result. The extent of emission reduction by the project has amounted to be approximately 20,000 tons of SO_2, 13,000 ton of NOx, and 124,000 tons of TSP.

Table 10: Simulation of Amount of Pollutants Emission Reduction
(1 Year after Completion: 2015)

Category	SO_2 emission (t/yr)	NO_X emission (t/yr)	TSP emission (t/yr)
Natural gas	365	1,969	166
Standard coal	21,262	15,083	124,584
Amount of emission reduction	20,897 (21,864)	13,114 (7,432)	124,418 (N/A)

Source: Calculated by the evaluator based on responses to questionnaires of Baotou City
Note: The figures in parenthesis are the target values at the time of appraisal.

As we used different estimation conditions from those that were used for target values at the time of the appraisal,[8] we cannot make simple comparison; however, with regard to target values, as the amount of SO_2 emission reduction is 21,864 (t/yr) and

[7] We had a reply from the Environmental Protection Bureau of the Baotou Municipal People's Government saying that the data regarding amount of pollutant emission cannot be disclosed as they are confidential. For this reason, in this report, the evaluator carried out estimation by comparing the amount of pollutant emission in case an equivalent amount of standard coal equivalent to the current amount of natural gas being supplied were used, with the amount of pollutant emission in case of natural gas. The estimation was carried out on the following assumptions. The amount of coal used (1,661,117 tons) when the amount of natural gas supplied in 2015 is converted to that of standard coal, amount of energy for natural gas: about 8,604 kcal/m^3 with energy efficiency of 80% and the amount of energy for standard coal: about 7,004 kcal/t with energy efficiency of 40%. As for the amount of pollutant emission of natural gas and standard coal, we used standard coefficients in consideration of the results of the interviews.

[8] At the time of the appraisal, it is assumed that all the sources of pollutant coming from the respective energy sources used by those enterprises that are scheduled to be converted to natural gas in this project as well as respective amounts of energy used in those general households that are assumed to convert to natural gas are all converted to natural gas.

the amount of NO_X emission reduction is 7,432 (t/yr), the target value for NO_X has been achieved.

A scene of heavy industrial area before implementation of the project

A scene of heavy industrial area after implementation of the project

3.3.2 Qualitative Effects (Other Effects)

The effectiveness regarding the environmental improvement of the city will be discussed below in "Impact". As for other effectiveness, the effectiveness of the training through this project is worth mentioning. Although the number of training programs in Japan was reduced from three to one, as the participants gave positive comments that the knowledge and experience gained in the training program has positively impacted the operation of their business, we can evaluate that the program had positive effects, particularly on raising safety awareness. In the following section, aspects mentioned in concrete terms, particularly in regard to safety area, are summarized in four points.

(1) Effects of the Training Program in Japan

At the time of the field study, we interviewed Mr. Yan-lei Sun, current Deputy General Manager[9] of Baotou Fuel and Gas Co., Ltd., with regard to the effectiveness and what was learned in the training program in Japan. Mr. Sun, who has been involved in process management since the beginning of this project, gave an assessment that the training program in Japan was effective in both short-term effects in the implementation process of the business and long-term measures for managerial improvement of Baotou Fuel and Gas Co., Ltd., as a whole. It is fair to say that, as the objective of the training program in Japan is to learn construction, engineering work, and maintenance of natural gas pipelines as well as the advanced managerial experience of the gas company, it is highly effective particularly for improvement of

[9] General manager is the name of an office/post in China which is equivalent to president in a Japanese company.

“safety” awareness. In the interview with Mr. Sun, we were able to confirm his view that acknowledges the learning and effects from the training in the following concrete aspects.

1) Change of Business Plan and Specifications

After listening to the experience at the time of the Great Hanshin Earthquake, they changed the specifications for medium pressure gas pipeline and low-pressure gas pipeline to use PE as the material of the pipe, as it has better quake-resistant characteristics and durability.

2) Systematization to ensure safe operation

While visiting Japanese gas companies, they became aware of the importance of the safety management system of the gas supply facilities; this awareness became a momentum towards accelerated introduction of an automatic control system.

3) Awareness concerning importance of human resources development

As improvement of the skills of employees, particularly maintenance skills, also leads to safe operation, they established an in-service training institute which provides practical training and introduced, from 2013, a program which puts more emphasis on practical training for new employees.

4) Awareness concerning importance of public relation activities for the purpose of improving penetration rate

After witnessing the situation in Japan where Japanese gas companies engage in such public relations activities as cooking classes for housewives, briefing sessions, and annual “Day of Gas”, they decided to improve the content of customer service and engage in PR activities for introduction of gas alarms to ensure the safety of users, resulting in an increase in the use rate from 20% to 90%.

A scene of discussion with
Mr. Yan-lei Sun

3.4 Impacts

3.4.1 Intended Impacts

Improvement of atmospheric environment and living environment of the residents in Baotou City is analyzed from the following points of view. With respect to quantitative effectiveness, effectiveness of atmospheric environment improvement based on the statistical data will be discussed; and, in regard to qualitative effectiveness, the effectiveness of this project will be described based on the opinions of the residents expressed in the results of beneficiary survey.

(1) Quantitative Effectiveness

1) Improvement of Atmospheric Environment in Baotou City

As shown in the figure below, compared with the situation at the time of the appraisal (2004), improvement is evident, as SO_2 emission concentration, NO_X emission concentration, and TSP emission concentration in 2015 are all on downward trends. As all these substances meet, in terms of annual average, the Class-2 national standards, it can be evaluated that a certain level of atmospheric environment is maintained even with the current national standards.

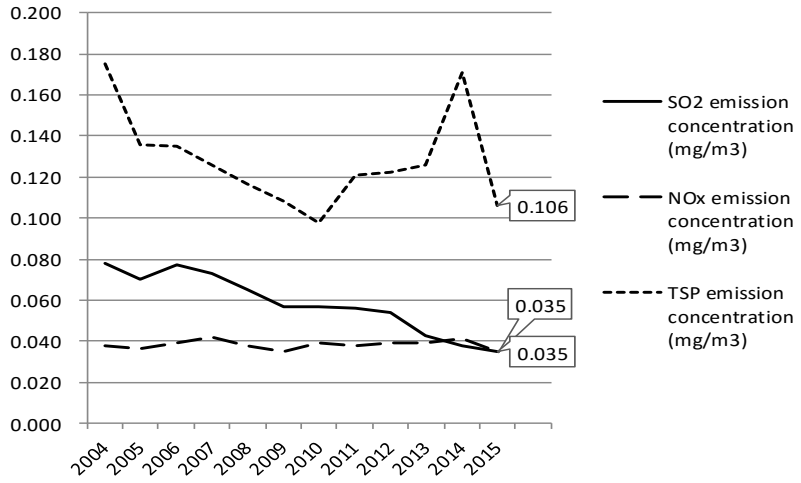


Figure 1: Status of Atmospheric Pollution – Year to Year Data
(Annual Average Concentration)
Source: Data provided by Baotou Fuel and Gas Co., Ltd., obtained from the Environmental Protection Bureau of Baotou Municipal People's Government

The figure below shows yearly data of how many days in a year the atmospheric quality in Baotou City met the Class-2 national air quality standards. Although only 178 days out of 365 days satisfied the standards at the time of the appraisal, the rate increased to as much as 329 days in 2015, satisfying the target of Baotou City's

Environmental Protection of the 12th Five-Year Plan. As shown in Table 3, as economic growth continues in Baotou City, the number of heavy industrial plants is also increasing. As this project is playing an important role as a source of gas supply for these industries, it can be evaluated that it is making a positive contribution to air pollution control for the city as a whole.

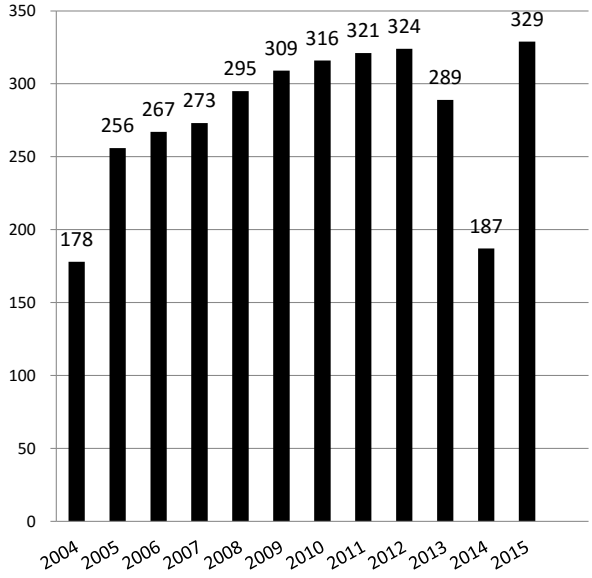


Figure 2: Number of Days Achieving the Class-2 National Standards
Source: Data obtained by Baotou Fuel and Gas Co., Ltd., from the Environmental Protection Bureau of Baotou Municipal People's Government

2) Qualitative Effectiveness

With respect to qualitative effectiveness of environmental improvement in Baotou City and improvement of living environment for the residents, we conducted a survey of 120 beneficiaries[10] from 120 households to confirm the positive change of living environment and the effectiveness brought about by the conversion to natural gas on people's lives.

With respect to improvement of living environment in Baotou City, when we asked questions about housing environment and atmospheric environment, and matters related to health in comparison with those of approximately 10 years ago; i.e., at the time of commencement of the project, more than 75% of the respondents answered, "it became better/has been improved" in relation to all items. Among other things, we were able to confirm those opinions that give a positive assessment to the explicit change of immediate living environment by the conversion to gas; for example, as a

[10] We conducted the survey by randomly extracting, as object of the survey, 120 households living in four districts of Baotou City (Qingshan, Kundulun, Donghe, and Jiuyuan districts), the targeted area of supply by this project, since 2005. The survey was conducted by face-to-face question and answer session by a researcher, obtaining 120 valid responses. Survey implementation period: the middle of December 2016.

result of conversion to gas, as they have fewer opportunity to use coal inside the house, they are generating less soot and dust.

Table 11: Improvement of Living Environment in Baotou City

Item	Result of answers and main opinions
	For residents (120 households)
Improvement of living environment compared with 10 years ago	"Improved" was selected by 94 people (78%). Main reasons include "Soot and dust was reduced" and "There is no need to stock coal now."
Improvement of atmospheric environment compared with 10 years ago	"Considerably improved" was selected by 92 people (77%). Main reasons are "Air became clean," "Dust was reduced," and "Living environment became clean."
Improvement in health compared with 10 years ago	"Considerably improved" was selected by 90 people (75%). Main reasons are "Sinus condition has improved," "Coughing was reduced," "Health conditions have improved," "I no longer need to wear a mask when I go out," "Breathing has become easy" and "Skin became better."

Source: Survey of beneficiaries

According to the beneficiary survey, not only did all the respondents completely convert their cooking equipment to natural gas, but many households also converted their hot water systems and heating devices to natural gas. Further, with respect to those pieces of equipment that have not been converted to natural gas at the moment, about 70% of respondents answered that they want to carry out conversion in the future because they have received a subsidy for the cost of natural gas conversion. As for other reasons for the change, apart from receiving a subsidy for the cost of natural gas conversion, "Natural gas is cheaper" and "It's good for air environment" are reasons many of them quoted for the selection.

As discussed above, the concentration of air pollutants in Baotou City has significantly improved, and it has improved to the level that achieves the current national air quality standards. As discussed in "Effectiveness" above, since the main role of the natural gas in this project is to be supplied to heavy industrial plants, etc., which are the main source of pollution in Baotou City, it can be evaluated that it is playing a major role in improving the air quality in the city as a whole. In addition, as the results of the beneficiary survey support the finding that improvement of the air quality has progressed in such way that local residents can actually feel it, it is evaluated that, in terms of both quantitative and qualitative aspects, the impact, i.e., improvement of atmospheric environment and improvement of level of living environment for the residents, has been achieved.

Air environment of Baotou City
(at the time of field study in October 2016)

3.4.2 Other Positive and Negative Impacts[11]

(1) Impacts on the Natural Environment

As this project is classified as category B under the "JBIC Guidelines for Confirmation of Environment and Social Considerations" (established in April 2002) at the time of appraisal[12], it is not assumed that there will be a significant negative impact on the environment. During the project period, no problems that were not assumed in the environmental impact assessment report have arisen, and there were no particular negative impacts on the natural environment.

(2) Land Acquisition and Resettlement

As the gas pipeline network was laid down in accordance with city planning avoiding residential areas, there has been no relocation of residents. If agricultural products had been cultivated at a site where gas pipeline was buried, as harvesting could not be done temporarily, compensation has been paid in accordance with the estimated harvest at that site. With respect to the payment, the user of the land and the constructor made an agreement in conformity with the domestic law.

(3) Unintended Positive and Negative Impact

As the gas company, at the time of construction, took such necessary measures as adherence to regulations concerning work time and installation of soundproof huts to reduce the work noise in accordance with the "People's Republic of China Environmental Noise Pollution Control Act" established in 1997, there has been no case of compensation payment, etc. paid because of noise.

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[11] Based on answers to the questionnaire by Baotou Fuel and Gas Co., Ltd., and additional confirmation with the person in charge of the site at the time of the project implementation.

[12] The environmental impact assessment report of this project was approved by the Environmental Protection Bureau of Inner Mongolia Autonomous Region in November 2004 (based on the documents provided by JICA).

In addition, with respect to measures against soot and dust, as the company took such measures as placement of sprinkler trucks and shielding off of the work area in accordance with the "People's Republic of China Environmental Protection Act," the "People's Republic of China Air Pollution Control Act," and other law and regulations concerning prevention of soot and dust, there has been no compensation payment, etc. paid because of soot and dust problem.

This project has achieved its objectives. Therefore, effectiveness and impact of the project are high.

3.5 Sustainability (Rating:③)

3.5.1 Institutional Aspects of Operation and Maintenance

(1) Project Implementation Structure

There has been no change of the plan since the time of the appraisal; and, the leading group of the Inner Mongolia Autonomous Region Atmospheric Environment Improvement Project was authorized to make decisions concerning important matters of this project, being a body in charge of formulation of relevant policies, coordination with relevant organizations, and implementation of loans. As the secretariat for this, the Inner Mongolia Autonomous Region Environment Improvement Project Japanese ODA Loan Management Office was established at the same time to be in charge of concrete operations. As for the implementing organization of this project, Baotou Fuel and Gas Co., Ltd., a holding company 100% owned by the state, was commissioned to carry out the operation.

(2) Structure of Operation and Maintenance after the Completion of the Project

Although the Financial Affairs Agency is in charge of governmental portfolio after the completion of the project, as many people have been continually in charge of this project since the planning stage, the continuity of policies and operation and collaboration between relevant organizations are both maintained well. Baotou Fuel and Gas Co., Ltd., the implementing agency, is currently providing 100% of natural gas in the city. The supplier of natural gas is Western Natural Gas Co., Ltd. in the Inner Mongolia Autonomous Region, with which it has concluded a 30-year long-term supply contract up to 2034. The number of employees is 598 (451 during implementation of this project) of which engineering employees account for about 50%. Although the number of engineers was expected to be 202 at the time of the appraisal, it was increased to be as many as 270 now; and the company has developed a system sufficiently capable of handling the operation in terms of scale as well. The operation

and management system has been systematized and, as shown below, inspection items and person in charge for individual facilities, inspection frequency, etc. have all been stipulated in great detail.

Table 12: Maintenance and Management System of the Main Facilities and the Management Details

Facilities	Prescribed frequency/ number of times, etc.	Inspection details
Gate Station	360 times/month; nine people are assigned to each station	Operational status of the facility, confirmation of operational data, checking of gas leakage, etc. On top of above, weekly routine inspection, cleaning of filters to remove foreign matters, monthly tuning test, large-scale inspection once a year and once in three years (overhauling, etc.)
Regulating Station	Four times/month; five people are assigned to each station	As above
Regulating Boxes	Four times/month; 20 people are assigned	As above
Gas Pipeline	30 times/month; 35 people are assigned	Confirmation of operational status of the gas pipeline, confirmation of the status of construction work on the ground, leakage inspection, etc.

Source: Responses to questionnaires of Baotou Fuel and Gas Co., Ltd.

As the number of employees is being increased to expand the destination of natural gas and to strengthen safety measures, it is considered that stable business operation will continue to be maintained in the future. In terms of structure, as privatization is not scheduled in the future, it is considered that there will be no major organizational changes in the immediate future either.

3.5.2 Technical Aspects of Operation and Maintenance

As stated above, Baotou Fuel and Gas Co., Ltd., is in charge of all the gas supply in the city; and, on the basis of the experience of business operation so far, the company has sufficient experience and knowledge base in the area of maintenance as well. As a result of the interviews with the people in charge of relevant facilities at the time of the field study, we were able to confirm the following details:

- At all outputs, the local employees had a good understanding of the framework for inspection implementation work as their routine duties and were able to explain it in an accurate fashion. In addition, with respect to handling of the emergency situation, a communication system and mobilization system are established in a

proper fashion including cooperation with on-site patrol teams, resident technicians, and the central control room of the headquarters of the gas company.

- Engineers belonging to the company are required to obtain technical qualifications according to the company regulations. In addition, they are employed after they go through the training course. Technical provisions associated with safety management such as acquisition of certificate of operation for relevant facilities have been developed and current engineers have all satisfied these provisions.
- The company implements in-house training courses targeting its engineers 12 times a year; not only courses for existing technologies, but also when the company introduces a new technology; in addition, the company formulates an annual plan for training.

On the basis of above, it is fair to say that Baotou Fuel and Gas Co., Ltd., has technical capability required for the sustainability of project effects.

Demonstration of gas pipe replacement work at the training center

Patrol car and the person in charge

3.5.3 Financial Aspects of Operation and Maintenance

According to the plan at the time of the appraisal, the funds required for the implementation of this project were scheduled to be supplied by Japanese ODA Loan, loans from domestic banks and private funds of Baotou Fuel and Gas Co., Ltd.; this project was implemented according to the plan without the need for supplementary expenditure from the government.

As the organization commissioned to implement the project, Baotou Fuel and Gas Co., Ltd., operates on a stand-alone basis; the company never had supplementary funding from the government in relation to its business operation. There is no plan to receive supplementary funding from the government in the future, either, as the company keeps operating in the black year after year from the time of implementation of this project to now. The table below shows major management indicators for the

most recent three years.

Table 13: Recent Management Status of Baotou Fuel and Gas Co., Ltd.

Unit: million yuan

	2013	2014	2015
Gross sales	1,060	1,155	1,241
Year-on-year		108.9%	107.5%
Gross profit on sales	383	418	350
Gross margin percentage	36.1%	36.2%	28.2%
Business profit	337	370	334
Operating income margin	31.8%	32.0%	26.9%
Current net earnings	287	322	292
Capital-to-asset ratio	25.8%	29.7%	21.0%
Liquidity ratio[13]	122.7%	124.9%	106.6%

Source: Calculated by the author on the basis of the data provided by Baotou Fuel and Gas Co., Ltd.

As the company has achieved stable business profit each year with a high level of income margin, it can be said that the company has been able to manage the business in a stable manner on the basis of its business income. According to Baotou Fuel and Gas Co., Ltd., in addition to charging for supply of gas, it also sells, for example, gas utensils for general households (kitchen goods, hot water utensils, etc.) for the sake of stable management. Further, Table 14 shows the trend of gas rate year-by-year, which shows that it increased by as much as 30% to almost 200% compared to that of 2004 or at the time of appraisal.

Table 14: Natural Gas Rate in Baotou City

Unit price per m^3	2004 (at the time of appraisal)	2016 (figures in parentheses show comparison with the time of planning)
Residential use	1.45 yuan	1.82 yuan (126%)
Industrial use (depends on the scale)	0.98–1.15 yuan	1.74–2.246 yuan (178-195%)
Public facilities	1.45 yuan	1.82 yuan (126%)
General business	1.7 yuan	2.346 yuan (138%)

Source: Data provided by Baotou Fuel and Gas Co., Ltd.

[13] For reference, in case of Japanese gas companies, the figures are: Tokyo Gas (2013: 157%, 2014: 151%, 2015: 155%) and Saibu Gas (2014: 96%, 2015: 70%).

Gas rate is set by the Baotou Municipal Government (Development and Reform Commission); when the government revises the rate, market research is carried out in advance by the Development and Reform Commission so that the setting of the rate is adjusted in such manner that Baotou Fuel and Gas Co., Ltd., maintains a certain profitability. In addition, it is possible for Baotou Fuel and Gas Co., Ltd., to apply for review of the gas rate to the Development and Reform Commission; in fact, the rise of gas rate from 2009 to 2010 was the result of an application submitted by Baotou Fuel and Gas Co., Ltd.

On the basis of above, being an entity operating on a stand-alone basis, the management status of Baotou Fuel and Gas Co., Ltd., can be described as generally good considering that it not only has stable income from gas supply business and sales of gas appliance to households, but also is trying to diversify its income base. It is fair to say that it has a sufficient financial base to continue to manage & maintain the natural gas business in the future.

3.5.4 Current Status of Operation and Maintenance

The status of operation and maintenance of each gas supply system is given in the respective paragraph as follows.

(1) Stability of Gas Supply and the Conditions of Main Facilities

As stated in “Effectiveness,” the gas pipeline network of Baotou City is structured as a loop network. There has been no record of interruption of gas supply by inspection work, etc. since the start of gas supply through this project. There has been no interruption of gas supply at any stations where we had field tours, including the Western Gate Station, the regulating station built in the aluminium plant, and the regulating station built in a residential area. In addition, there has been no record of repair work apart from replacement of consumable parts.

With respect to the gas pipeline in Baotou City as a whole, the aging sections are being replaced one by one; on that occasion, the steel pipes that have been used in the past are changed to PE pipes. In addition, there are around ten cases of reports of gas leak from the general public and identification of gas leakage by the employees; apart from these, there are a few times of emergency dispatch in a year because someone has broken the gas pipeline and so on.

The current amount of natural gas supply by Baotou Fuel and Gas Co., Ltd., is approximately 580 million m^3/year; and, it is expected that it will increase by 20% every year. Although the capacity of supply with the current system is 1,000 million m^3/year, as it is highly likely that the company needs to expand its supply capacity in

the future, and it is making necessary investment in plant and equipment to ensure continual gas supply in Baotou City even after the ODA Loan project; for example, by its own funds, it is not only replacing aging gas pipeline, but also replacing the existing pipes with larger diameter ones in preparation for increased amount of gas supply. No particular problem was identified in this area.

(2) Conditions of the Control System

The SCADA system introduced to the central control room is being updated as needed in response to the increase in number of stations. As engineers dedicated to the maintenance of the SCADA system (updating and programming) are stationed in Baotou Fuel and Gas Co., Ltd., at the moment, it is operating without a problem.

From the perspectives stated above, it is fair to say that maintenance and operating conditions of outputs will continue without a problem.

No major problems have been observed in the institutional, technical, financial aspects and current status of the operation and maintenance system. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

This project was carried out in Baotou City, an industrial center of the Inner Mongolia Autonomous Region, to construct a natural gas pipeline that should help facilitate energy transition from coal to natural gas and reduce emissions of air pollutants with a view to improving the air quality of the city and raising the levels of living and environmental standards of the people there.

This project is highly relevant, as it agreed with the air pollution countermeasures specified in the development plan from the time of appraisal to the present at all of the national, autonomous region, and city levels. Efficiency of the project is fair, as both the project cost and project period exceeded the plan. However, influences of the delay were controlled with some measures adopted to improve efficiency, such as replacement of materials and machines with better ones and enhanced efficiency of construction work. The gas supply has achieved the target set for the amount of gas to be supplied, and since the completion of the project, stable distribution has been maintained, with no supply interruption. That has enabled the city to replace coal, an inefficient combustion source, and reduce pollutants in the atmosphere. In 2015, the concentration of pollutants in the air was controlled below the national criteria on more than 90% of the days. As people living

there notice improvements in air and living environments, effectiveness and impact of the project are high. The organization operating this project has achieved stability in all of organizational, technical, and financial aspects. Therefore, 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 Executing Agency

None

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Realization of enhanced project effects by comprehensive measures of environmental improvement

This project has achieved significant effects; and one of the important factors for this is implementation of appropriate policies and measures to facilitate the effectiveness of this project. To promote conversion to natural gas, it is important to encourage users to convert from existing energy; therefore, in this project, smooth conversion to natural gas was facilitated by encouraging people to abandon inefficient coal boilers at the same time. In addition, with regard to gas rate, financial sustainability was achieved by setting a rate structure which ensures certain profitability. It is fair to say that such stable financial base is also effective in maintaining stability and reliability of gas supply. It also seems that this project has produced excellent project effects, by virtue of having been implemented in conjunction with a package of policies which help enhance the effects of the project. When a project is aimed at conversion of the energy source for an entire city like this project, in many cases, it involves development of basic infrastructure. Thus, it becomes important to focus not only on the physical development through the project, but also on the enhancement of the policy effect by introducing such policy measures that facilitate its effectiveness.

Comparison of Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs 1) Western Gate Station of Baotou City: 1 set	New construction	Almost as planned (change of location)
2) Donghe Gate Station of Baotou City: 1 set	Expansion	As planned
3) Kundulun District Regulating Station (High/ Medium Pressure): 1 set	New construction	As planned
4) Development Zone Regulating Station (High/ Medium Pressure): 1 set	Expansion	As planned
5) Special-purpose Regulating Station (High/ Medium Pressure): 1 set	New construction: 8 plants Expansion: 3 plants	New construction: 6 Plant expansion: As planned
6) Regulating Boxes (Medium/ Low Pressure)	New construction: 120 units	New construction: 110 units
7) Gas Pipeline	・High pressure gas pipeline New construction: 54 km ・Medium pressure gas pipeline New construction: 52 km Rebuilding installation and replacement: 270 km ・Low pressure gas pipeline Rebuilding installation, and replacement: 441 km	Total length for each gas pipeline: ・High pressure gas pipeline: 48.66 km ・Medium pressure gas pipeline: 325.24 km ・Low pressure gas pipeline: 468.18 km
8) Nozzle adjustment and repair of inner tube of gas equipment	Number of targeted households: 147,000	As planned
9) SCADA system	1 set	As planned
10) Valves	・For high pressure: 15 units ・For medium pressure: 100 units ・For low pressure: 300 units	As planned
11) Training program in Japan concerning atmospheric environment improvement	3 groups (12 in total)	1 group (5 in total)
2. Project Period	March 2005 - December 2013 (106 months)	March 2005 - August 2014 (114 months)
3. Project Cost Amount Paid in Foreign currency	8,469 million yen	8,443 million yen
Amount Paid in Local Currency	5,493 million yen	6,908 million yen
	(413 million yuan)	(413million yuan)
Total	13,962 million yen	15,351 million yen
ODA Loan Portion	8,469 million yen	8,443 million yen
Exchange Rate	1 yuan = 13.3 yen (As of September 2004)	1 yuan = 14.77 yen (Average between 2005 and 2015)
4. Final Disbursement	July 2014	

People's Republic of China

FY2016 Ex-Post Evaluation of Japanese ODA Loan

"Henan Province Afforestation Project"

External Evaluator: Shima Hayase

0. Summary

The Henan Province Afforestation Project (hereafter referred as the "Project") aims to enrich forest resources by afforestation in Henan Province, thereby contributing to suppression of soil erosion in mountainous areas and strong winds in plains, mitigating damage of natural disasters such as floods and sandstorms in the area, and improving the living environment.

The Project was prompted by the increase in importance of afforestation because of the escalation of natural disasters in the Yellow River and the Yangtze River basin areas at the time of appraisal. The Project's relevance is high because its aim is consistent with the Chinese Government's development policies, development needs and the aid policy of Japan. The targets on the enrichment of forest resources such as artificial afforestation area, forest coverage ratio, survival/preservation rate, and stock volume[1] were achieved. The Project implementation area was equivalent to 13% of the area afforested in the province during the same period; also the project contributed to improving the forest coverage ratio and stock volume in the province. Regarding the improvement of life, although the Project's economic effect from afforestation has not yet been developed, the Project yielded certain effects on reducing natural disasters such as deterrence of approximately 9% of the soil erosion and suppression of strong winds. Thus the effectiveness and impact of this project are high. With regard to the efficiency, the project cost was within the planned limit, though the project period exceeded the plan due to the extension of afforestation period. Thus the efficiency of the Project is fair.

At the time of ex-post evaluation, there was no change in the structure of the executing agency, and a structure to support forest management has been established. Because the central government allocated budget for national priority projects, funds for operation and maintenance including nursing and pest and disease control were secured in the province. The shortage was found in the maintenance costs of protection forests among some farmers and forest farms at the time of ex-post evaluation. However, the provincial forestry department had a policy to increase subsidy for the maintenance of protection forests for ecological purpose, thus in the medium term, the shortfall was expected to be resolved. Also, a few problems were observed in technical aspects, and the maintenance status, therefore the sustainability of the Project is fair.

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

[1] An indicator to measure the quantity of a forest (trunk of trees) by cubic volume, It shows the status of a forest per unit area.

1. Project Description

Project Location

Protection Forest of Poplar (Runan County)

1.1 Background

Henan Province in the central part of China is located in the upper middle watershed of the four major rivers[2], and 44% of its area is mountains and hills. In the province, the excessive deforestation to meet the demand for timbers and the expansion of cultivated land led to the soil runoff from mountain slopes where ground surface was exposed, and degradation of levee and dam due to soil sedimentation. Those were factors that worsened flood damage. Moreover, in the plain area, land surface exposed by overcutting, caused burial of roads and cultivated land at the time of sandstorms, and also soil flowage damages.

In the 71 project implementation counties, the economic loss due to natural disasters amounted to 26.6 billion Chinese yuan per year. In 2003, due to the floods caused by the heavy rain, 3,587 people suffered from damage, 73 people died, 420,000 houses collapsed, and the economic loss reached 18.2 billion Chinese yuan.

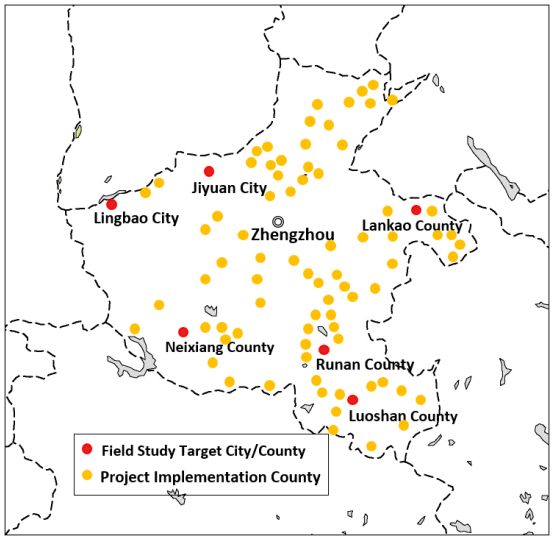
1.2 Project Outline

The objective of the Project is to enrich forest resources[3] by afforestation in Henan Province, thereby contributing to suppression of soil erosion in mountainous areas and strong winds in plains, mitigating damage of natural disasters such as floods and sandstorms in the area, and improving the living environment.

[2] Yellow River, Yangtze River, Huaihe River, and Haihe River

[3] The objective of the Project at the time of appraisal was "by afforestation in 71 counties of Henan Province, contributing to suppression of soil erosion in mountainous areas and of strong winds in plains, mitigating damage of natural disasters such as floods and sandstorms in the area, and improving the living environment." However, the target corresponding to the direct effects by afforestation (outcome) was not clearly set. Therefore, this evaluation translated, the expected outcome as enrichment of forest resources (artificial afforestation area, survival rate, forest coverage ratio, and forest stock volume etc.), and added them to the evaluation of effectiveness.

Loan Approved Amount/ Disbursed Amount	7,434 million yen/7,218 million yen	
Exchange of Notes Date/ Loan Agreement Signing Date	June 23, 2006/June 23, 2006	
Terms and Conditions	Interest Rate	0.75 %
	Repayment Period (Grace Period	40 years 10 years)
	Conditions for Procurement	General Untied
Borrower / Executing Agencies	Government of People's Republic of China / Henan Provincial People's Government	
Project Completion	August, 2012	
Main Contractor(s) (Over 1 billion yen)	-	
Main Consultant(s) (Over 100 million yen)	-	
Feasibility Studies, etc.	"Feasibility Study Report" Henan Provincial Forestry Planning Institution July, 2005	
Related Projects	【ODA Loan Projects】 ・Hubei Province Afforestation Project (L/A 2003) ・Jiangxi Province Afforestation Project (L/A 2003) ・Eco-Environmental Construction and Treatment Project in Sichuan (L/A 2005) ・Xinjiang Yining City Environmental Renovation Project (L/A 2005) 【Grant Aid Project】 ・Mother River Protection Afforestation Project (2000) 【Technical Cooperation Project】 ・Environment Construction at Co-existent Areas of Human Beings and Crested Ibis (2010) 【Other International Agency's Projects】 ・National Afforestation Project (World Bank 1990) ・Forest Resource Development and Protection Project (World Bank 1994) ・Forestry Development in Poor Areas Project (World Bank 1998)	



Source: made by the material provided by Henan Provincial Department of Forestry Project Office

Figure 1: Position of Project Implementation Counties within Henan Province[4]

2. Outline of the Evaluation Study

2.1 External Evaluator

Shima Hayase, IC Net Limited

2.2 Duration of Evaluation Study

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

Duration of the Study: August 2016 – October 2017

Duration of the Field Survey: October 24, 2016 – November 8, 2016, April 9, 2017 – April 13, 2017

2.3 Constraints during the Evaluation Study

As this ex-post evaluation was carried out four years after the Project completion (2012), it was premature to observe the Project's mid to long-term effects, and analyze future prospective conclusively. Accordingly, the ex-post evaluation focused on analyzing basic effect indicators, prospects for the development and sustainability of the Project's effects and the status of the institutional, financial and technical environment to realize the prospects. Also, because the forests were still growing and not ready for observation of their fully developed status, and the Project covered expansive areas in 75 counties in Henan Province, and it was impossible to visit all the project sites within the allocated study period, the Project's effectiveness had to be

[4] The cities and the counties for the field study were chosen by taking into consideration the impartiality of climate in the province, north, south, east, and west location, and the conditions of land. Eventually plain area (Lankao County, Runan County), mountainous area (Luoshan County, Lingbao City), and hill/ mountain area (Neixiang County, Jiyuan City) were selected.

provisionally evaluated by using the sampling data[5] collected through field survey.

3. Results of the Evaluation (Overall Rating: A[6])

3.1 Relevance (Rating: ③[7])

3.1.1 Consistency with the Development Plan of China

(1) Consistency with the Development Policy at the Time of the Appraisal

The Government of China established and announced *the National Plan for Ecological Construction (1998–2050)*, in January 1998 and set short/mid/long term numerical goals for natural environment restoration, and four areas[8] and agenda to be prioritized till 2010. In the plan, Henan Province corresponded to *the Yangtze River Upper and Middle Basin* and *the Yellow River Upper and Middle Basin* areas, and for each area numerical goals for soil runoff and afforestation area expansion were identified.

Moreover, in *the 10th Five-Year Plan for the National Economic and Social Development (2001-2005)*, an area for priority projects was set, and Henan Province was in the area of *the Natural Forest Protection Area in the Yangtze/ the Yellow River Upper and Middle Basin*.

(2) Consistency with the Development Policy at the Time of the Ex-Post Evaluation

From the time of appraisal, *the National Plan for Ecological Construction (1998–2050)* was continuously effective. Also in *the 12th Five-Year Plan for the National Economic and Social Development (2011-2015)*, Henan Province was in the area of various prioritized projects for natural environment protection/restoration, such as afforestation in the Yangtze/the Yellow river Upper and Middle Basin, for soil loss mitigation natural forest protection, building windbreak forests, and returning agricultural land at steel slope to forest project called *the Steep Farmland Conservation to Forestland* Therefore, the importance of afforestation projects has not changed in the national development policies and in Yangtze/the Yellow river upper and middle basin area including Henan province.

3.1.2 Consistency with the Development Needs of China

(1) Consistency with the Development Needs at the Time of the Appraisal

At the time of appraisal (2004), forest coverage ratio in Henan Province was 16.2%, which was lower than the national level of 18.2%, and excessive deforestation was cited as the cause.

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[5] The Project was implemented in vast areas consisting of 75 counties. Therefore, it was impossible to conduct a field study in all the project counties during the evaluation study period. To address this problem, the evaluation team asked the Henan Provincial People's Government , the implementing agency, to collect operation and effect indicators in all the counties In addition, the evaluation team chose representative areas to conduct field survey and beneficiary surveys in order to grasp the overall picture.

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

[7] ③: High, ②: Fair, ①: Low

[8] the Yellow River Upper and Middle Basin, the Yangtze River Upper and Middle Basin, Desertification Zone, Prairie Zone

The soil eroded in the mountain slopes where the surface was exposed by overcutting. In the 71 Project implementation counties, 140 million ton of soil eroded annually. The soil accumulated in the riverbed and dam lakes degraded the function of levees and dams, and were a factor that magnified the flood damage. In the plain areas, due to the wide surface runoff, damage caused by sandstorms buried roads and cultivated land, and soil runoff occurred in the cultivated land by strong wind due to insufficient protection by wind breaking forest. Based on the situation, Henan Provincial People's Government enacted the "Henan Province Greening Plan (2003)" and planned afforestation of 1.4 million ha by 2010 and of 2 million ha by 2020.

(2) Consistency with the Development Needs at the Time of Ex-Post Evaluation

In *the Henan Province 12th Five-Year Forestry Development Plan (2011-2015)* (announced on March 16, 2012), although the previous plan's targets were achieved, the forest area per capita was one-fourth of the national average, and because the share of mixed forests was small, the forest volume was about 46m^3/ha, which was about 53% of the national average of 86m^3/ha. Therefore, the delay in economical use of forest resources such as timber, and weak defense function against disasters, in addition to the delay in industrialization of forestry and forest management were pointed out. In response to the situation, the objectives were set to be achieved by 2015, the ending year of the plan, which were to raise the forest coverage ratio from 21.5% in 2010 to 23.61%, and to increase the forest stock volume to more than 159.6 million m^3, by conducting 933.3 thousand ha of artificial afforestation; 1,133.3 thousand ha of forest nursing (including low-efficiency forest rehabilitation); and tree plantation of 900 million seedlings by all the provincial residents.

In *the Henan Province Afforestation and Greening Project (2011-2020)*, about 1.8 million ha of artificial afforestation in 10 years, and nursing 240 ha of the existing forest were targeted.

The needs in afforestation have been consistent, also the consistency of the Project which was to implement artificial afforestation and low-efficiency forests rehabilitation, and to increase mixed forests in order to improve quality of forest has been high from the time of appraisal.

3.1.3 Consistency with Japan's ODA Policy

In all the policies, such as *the Economic Cooperation Plan for China* issued by the Government of Japan in October 2001, JICA's *Overseas Economic Cooperation Implementation Policy* and *the 2005 Fiscal Year Business Implementation Policy* of JICA, "environmental protection" was the area of priority. The Project's objectives such as afforestation, protection of natural forests, improvement of barren mountains, and sand prevention were consistent to the policies. Therefore, consistency to Japan's ODA policy is high.

3.1.4 Appropriateness of the Project Plan and its Approach

The counties for project implementation were selected according to the four principles below:

(a) Under target area for the Ecological Forest Protection Plan.
(b) A certain size of land is available for afforestation, and cooperation from township/village can be gained for the implementation.
(c) The county government agrees on fund provision and it has repayment capacity.
(d) There is no other forestry related investment projects.

Source: material provided by Henan Provincial Department of Forestry Project Office

Among the counties selected upon these principles, priorities were given to the following areas: mountains with steep slopes; flatlands in need of windbreak forest; lands where soil runoff had been progressing; and natural forests in need to be protected. In achieving the objectives of the Project, which were to reduce natural disasters and to improve environment by afforestation, the plan and its approach were appropriate.

In light of the above, the project implementation was fully consistent to the development policies of the Chinese Government and Henan Provincial Government, the development needs at the time of appraisal and ex-post evaluation, and Japan's ODA policy at the time of appraisal. Also the project implementation counties were selected according to the needs. Therefore the relevance of the Project is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

At the time of appraisal, the Project's envisioned outputs consisted of afforestation, procurement of material and equipment, and training. The plan and the actual of each item are as shown in Table 1.

Table 1: The Original and Actual Scope of the Project

Items	Plan	Actual	Difference
(a) Afforestation (unit: ha)			
Afforestation Area	**194,190 ha**	**197,031 ha**	**2,841ha**
Protection Forest	163,610ha	165,184 ha	1,574ha
Economic Forest	11,880 ha	12,580 ha	700ha
Timber Forest	18,700 ha	19,267 ha	567ha
(b) Procurement of Material and Equipment			
Signboard	2,202 locations	696 locations	∆ 1,506 locations
Pump	161 sets	141 sets	∆ 20 sets
Pesticide Spreader	172 sets	162 sets	∆ 10 sets
Building for monitoring	480 locations	251 locations	∆ 229 locations
Patrol Vehicle	71 sets	70 sets	∆ 1 set
(c) Training			
Overseas Training			
Forestry related department staff	20 persons 5times Total 80 persons	5 times total 107persons	27 persons
Training in China			
Provincial Level	N/A	5084 persons	N/A
County Level	N/A	25,245 persons	N/A

Source: material provided by Henan Provincial Department of Forestry Project Office

(1) Project Implementation Counties[9]

At the time of appraisal, 71 counties (69 cities/counties, 2 state-owned forest farms) were planned to implement the Project, but in reality, it was implemented in 75 counties (68 cities/counties, 7 state-owned forest farms). Two counties canceled participation before the beginning of afforestation, one was replaced, the afforestation area of a county were transferred to others, and the five state-owned forest farms that were a part of counties changed to county level unit. Consequently, there were no changes in the scope of the planned afforestation area in the Project as a whole.

(2) Afforestation Area

While the planned afforestation area was 194,190 ha, the actual was 197,031 ha (101% of the planned), which is almost as planned at the time of appraisal. Breakdown by type of forest, plantation and afforestation area was almost the same as the plan.

[9] The implementation unit was written as "county." However, it included cities and state-owned forest farms, which were also counted as one unit.

Table 2: Plan and Actual of Afforestation (unit: ha)

Plan at Appraisal (2006)					
Forest Type[10]/ Plantation Type	Artificial Afforestation	Mountain Closure[11]	Low Efficiency Forest Rehabilitation[12]	Middle-Young Forest Tending[13]	Total
Protection Forest	115,660	36,600	11,350	—	163,610
Economic Forest	8,880	—	3,000	—	11,880
Timber Forest	7,300	—	—	11,400	18,700
Total	**131,840**	**36,600**	**14,350**	**11,400**	**194,190**
Actual (2016)					
Forest Type / Plantation Type	Artificial Afforestation	Mountain Closure	Low Efficiency Forest Rehabilitation	Middle-Young Forest Tending	Total
Protection Forest	117,129	37,053	11,003	—	165,184
Economic Forest	9,680	—	2,899	—	12,580
Timber Forest	7,508	—	—	11,759	19,267
Total	**134,317**	**37,053**	**13,902**	**11,759**	**197,031**
Ratio to Plan	102%	101%	97%	103%	101%

Source: material provided by Henan Provincial Department of Forestry Project Office

(3) Number of Participants and the Afforestation Area

Participating farmers of the Project were selected by public offering. The actual number of farmers/forestry famers, united farmers[14] and their afforestation area were almost as the same as the plan at the time of the appraisal. The number of collective forest farms[15] and the afforestation area were drastically decreased to 35% of the plan. This was because the form of collective forest farm has been decreasing nationwide. The forests which were important for an environmental protection were designated to the state's protection and they has been nationalized and managed with subsidies. Originally, 32 state-owned forest farms planned to participate, however, in reality, the number increased significantly to 143 farms, and the afforestation area also increased to 442% of the plan. The reason was that revenues could not be expected from mountain closure, which was planned at the time of the appraisal, and the afforestation allocation area was replaced from farmers to state-owned forest farms.[16]

[10] According to the "Forestry Law of China", Protection Forest is a forest or shrub group purposed for water conservation, soil retention, engineering sand fixation, and farm land protection etc., Economic Forest is purposed mainly for producing fruits, industrial material and Chinese herbal medicine etc., and Timber Forest is mainly for timber production.

[11] A method taken in a forest where density is low but natural reproduction can be expected with supplemental planting and nursing, and by surrounding the area with fence.

[12] A method to improve the quality of a forest by thinning and/or artificial afforestation etc. where are devastated or whose economic value is deteriorated due to overcutting, planting wrong tree species that do not match the land condition or planting low quality seedling.

[13] A method to promote the growth of the trees in young forests by thinning and nursing such as pest prevention

[14] A coalition of farm households which is for the farmers to cooperate in agricultural work and shipment etc.

[15] Forest farms managed by the local farmers whose forest lands used to be the possession of the People's Government Corporation and are delegated to the local community.

[16] Participants of this project were selected by public offering. Regarding the allocation of afforestation area, forest type, plantation type, adjustments were made according to the characteristics of the land that the participant has a right to use, the natural conditions, etc. and the overall goal. Especially for small-scale farmers, consideration was given to allocate more economically beneficial economic and timber forests from the viewpoint of poverty alleviation, while for large-scale farmers and state-owned forest farms, more area of protection forests and mountain closure that emphasize ecological effects were allocated.

Table 3: Number of Participants and the Afforestation Area (unit: household)

	Plan at Appraisal (2006)		Actual (2016))		Ratio to Plan	
	Number of Participants	Afforestation Area	Number of Participants	Afforestation Area	Number of Participants	Afforestation Area
Farmers / Forestry Farmers	300,000	145,340 ha	301,610	145,980 ha	101%	100%
United Farmers	1,000	8,500 ha	1,029	8,746 ha	103%	103%
Collective Forest Farms	250	33,400 ha	87	11,555 ha	35%	35%
State-Owned Forest Farms	32	6,950 ha	143	30,750 ha	143%	442%
Total	301,282	194,190 ha	302,869	197,031 ha	101%	101%

Source: material provided by Henan Provincial Department of Forestry Project Office

(4) Procurement of Material and Equipment

Procurement of material and equipment related to afforestation and conservation of forest decreased overall because some items were purchased with the domestic project budgets between the time of appraisal and the beginning of the Project and these items were eliminated. The number of signboards for mountain closure was greatly reduced since they were excluded at the sites, which already had signboards. In the plan, monitoring buildings[17] planned to be constructed in 480 locations, but in reality, the number was half the plan. This was due to the fact that in the plain area there were no lands available for constructing buildings because the surrounding areas were agricultural lands, and that monitoring building was unnecessary in forests neighboring the villages. No issues occurred, and alternative input was unnecessary also because forest monitoring was possible from agricultural lands or from the villages.

(5) Training

1) Overseas Trainings

The original plan was to conduct training on afforestation technology (revegetation technique, forest management) at Shinshu University in Nagano Prefecture as a recipient institution. While originally 80 staff members of forestry related departments in the municipal governments (province, city, counties) were planned to participate, in reality 107 staff members[18] (134% of the plan) participated. Moreover, additional destinations were included and meetings with engineers from the following locations took place: Mie Prefecture (artificial forest management, seedling management field, forestry product utilization); Tokyo (urban greening); and Hokkaido (forests, municipality greening, soil conservation facility). After the trainings, some of the participants conducted joint research with the Shinshu University on technology of pot seedlings plantation in mountainous areas, where the natural

[17] Subsidies to construct a brick building per 400 ha of protection forest, and per 200 ha of timber and economic forest were planned.

[18] The participants of the overseas training consisted of 92 men and 15 women.

environment are severe, and put the findings into practical use.

2) Trainings in China

While the details of the plan were unknown, the actual results were as follows:

(a) Trainings at provincial level : Trainings on project management and financial administration for city/county project administration offices, and trainings on forestry technology (environmental conservation, forest management, nursing, pest and disease control) for engineers were conducted 13 times, and a total of 5,084 officers and engineers attended.

(b) Trainings at county level : Trainings on project management for the county/township project administration offices and trainings on forestry technology for engineers were led by the city/county staff who attended provincial-level training. A total of 25,245 participants attended 11 courses of training. The trainings for engineers were conducted for township and forest farm staff, and the Project participants. The subjects contained field management and management technique corresponding to type of forest, which were more practical compared to the provincial-level trainings.

3.2.2 Project Inputs

3.2.2.1 Project Cost

At the time of the appraisal, the project cost was planned to be 11,444 million Japanese yen (480 million Japanese yen in foreign currency; 10,964 million Japanese yen in domestic currency). The actual cost was 10,966 million Japanese yen (258 million Japanese yen in foreign currency; 10,708 million Japanese yen in domestic currency), which was within the plan (96% of the planned cost). Actual procurement of material and equipment was less than the plan, but it was influenced by the exchange rate[19]fluctuations.

3.2.2.2 Project Period

In the plan, the project implementation period was scheduled from June 2006 to September 2011 (64 months) [20]. Actually, it was from June 2006 to August 2012 (75 months), and the project period was longer than planned (117% of the plan). Afforestation completion was planned in the winter of 2008 at the time of appraisal. However, the actual afforestation completion was the spring of 2010, which caused extension of the Project period more than a year.

[19] At the time of appraisal, 1 Chinese yuan=13.7 Japanese yen was applied for conversion. In reality, the average exchange rate during the Project's expenditure (2007-2014) was 1 Chinese yuan =14.23 Japanese yen, thus the total Project cost converted in Japanese yen became smaller.

[20] The definition of the Project completion was passing the third-growing year inspection on preservation rate.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

The economic internal rate of return (EIRR) was recalculated with the actual cost and benefit provided by the executing agency. Although it was 14.2% at the time of the appraisal, because the project cost was less than the plan, it was 16.6% at the time of ex-post evaluation (Table 4).

Table 4: Comparison of EIRR at Appraisal and the Ex-Post Evaluation Time

Appraisal[21] (2006)	Actual (2016)
14.2 %	**16.6 %**
Prerequisite Cost: Construction, Operation and Maintenance Benefit: Sales Proceeds of Timber/Fruits Project Life : 40 years	**Prerequisite** Cost: Construction, Operation and Maintenance Benefit: Sales Proceeds of Timber/Fruits Project Life : 40 years

Source: material provided by Henan Provincial Department of Forestry Project Office

As mentioned above, although the project cost was within the plan, the project period was significantly longer than the plan. Therefore, the efficiency of the Project is fair.

3.3 Effectiveness[22] (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

At the time of appraisal, quantitative indicators related to enrichment of forest resources such as area of artificial afforestation, forest coverage ratio, survival/preservation rate, and stock volume were set to confirm the Project's effects. In addition to the above, effectiveness was also checked based on the growth status of the trees in the forests at the field survey.[23]

Incidentally, because training was not a main component of the Project, its effects were to be evaluated in the technical aspect of operation and maintenance in the section on sustainability, but not in the section on effectiveness or impact.

(1) Artificial Afforestation Area

The target and the actual result of the artificial afforestation area (excluding mountain closure, forest rehabilitation, and middle-young forest tending) of the Project are shown in the below Table 5. The total area was 102% of the target. More artificial afforestation was built than the plan in all protection, economic and timber forests.

[21] The EIRR calculated at the time of appraisal was 13.6% but it was the figure with tax. Thus the evaluator recalculated EIRR by eliminating the tax.

[22] Effectiveness is to be evaluated together with Impact.

[23] The plan at the appraisal, the objective of the Project was set as "by afforestation (output), the project mitigates the damage of natural disasters such as floods and sandstorms in the area and improves the living environment (impact)". The logic corresponding to the outcome level was missing. In this evaluation, outcome was interpreted as enrichment of forest resources (indicators with targets such as artificial afforestation area, forest coverage ratio, survival rate and forest stock volume, and additionally preservation rate and the growth situation of the forests).

Table 5: Artificial Afforestation Area by Forest Type

Forest Type	Indicators	Plan at appraisal Completion Year (2011)	Actual Completion Year (2012)	Ratio to the Plan (%)
Protection Forest	New afforestation Area (ha)	115,660	117,129	101%
Economic Forest	New afforestation Area (ha)	8,880	9,680	109%
Timber Forest	New afforestation Area (ha)	7,300	7,508	103%
	Total	131,840	134,317	102%

Source: material provided by Henan Provincial Department of Forestry Project Office

(2) Forest Coverage Ratio[24]

The target at the time of appraisal and the actual result are as shown in the Table 6. The average forest coverage ratio of the Project implementation counties was 20.14%. Thus, the target of 20.1% was achieved.

Table 6: Forest Coverage Ratio of Project Implementation Counties

	Baseline (2004)	Target at Appraisal Completion Year (2011)	Actual Completion Year (2015[25])
Henan Province	16.2%	20%	23.6%
Project Implementation Counties	**18.4%**	**20.1%**	**20.14%**

Source: material provided by Henan Provincial Department of Forestry Project Office

(3) Survival Rate[26]/ Preservation Rate

The target of survival and preservation rates, and the actual average of project implementation counties are as shown below in Table 7. In all the forest type, survival rate (85%) and preservation rate (80%) achieved the targets.

Table 7: Survival Rate and Preservation Rate[27]

	Target			Actual		
	Protection Forest	Economic Forest	Timber Forest	Protection Forest	Economic Forest	Timber Forest
Survival Rate 1st Growing Year	85%			96%	96%	97%
Preservation Rate 3rd Growing Year	80%			87%	89%	90%

Source: material provided by Henan Provincial Department of Forestry Project Office

[24] Percentage of the forest area to the total area

[25] The Project completion was in 2012, which was the third growth period. However, because the forest ratio is measured every five years, this evaluation employed the neighboring data of 2015.

[26] At the time of appraisal of the Project, target was set only for the survival rate at the first growing year. Normally, preservation rate at the third growing year is included in afforestation inspection by the State. Therefore, in this evaluation, the preservation rate was also confirmed. According to the executing agency, the reason why preservation rate was not included in the target was that many of the participants of the Project were poor farmers, and in order to refund them the expenses for afforestation as early as possible, the agency set the survival rate as the condition for passing the inspection.

[27] For the mountain closure forests, setting signboards and fences, and barring entrance were the conditions for passing the forestry inspection. Thus, farmers did not have records regarding the forest density. Since no target was set for forest density, this evaluation did not use it as an indicator.

The average survival rate and the preservation rate according to the response of the beneficiary survey[28] are shown in Table 8. In all the forest types, the targets (survival rate 85%, preservation rate 80%) were attained. The majority of the farmers were able to achieve the targets, however 3 small-scale farmers[29] (3%) and 4 large farmers (4%) were not able to achieve the targets for the survival rate, and 1 small-scale farmer (1%) and 5 large-scale farmers (5%) did not achieve the target either for preservation rate. These farmers had been planting trees in the forests in severe natural environment.

Table 8: Average Survival and Preservation Rate of Beneficiary Survey

	Small-Scale Farmer			Large-Scale Farmer		
	Protection Forest	Economic Forest	Timber Forest	Protection Forest	Economic Forest	Timber Forest
Survival Rate 1st Growing Year	94.2%	97.0%	90.7%	93.4%	94.6%	91.4%
Preservation Rate 3rd Growing Year	90.9%	92.1%	86.7%	89.6%	90.4%	85.6%

Source: Beneficiary Survey

(4) Growth Status in the Forests

Considering the balance among the regional characteristics (plain, mountain, hill/mountain), the evaluation team selected 20 sites from six Project implementation cities/counties, and conducted a field survey to confirm planting techniques, growth status, and operation and maintenance status of the representative species of each afforestation type. The summary is described below:

1) Artificial Afforestation

Plain: Protection forest (Poplar, Tung tree) is the main type. Afforestation was carried out for the purposes of (a) wind breaking for roads and waterways, (b) improvement of degraded land and wind breaking, and (c) wind breaking for agricultural land. Since the plain area had better natural conditions such as water resources, the growth status and maintenance of the forests were good. Not only ecological effects such as wind breaking and sand prevention, but also economic effects from the sales of timbers can be expected in the future (Lankao County,

[28] A beneficiary survey was conducted to the farmers (a sample size: 199) participated in the project in six cities/counties (33,393 participants) which were selected from the 75 Project implementation counties balanced by regional characteristics. In each target city/county, two or three project implemented townships/villages were randomly selected, and a sample for the survey was extracted by a random sampling method from the participant list. Since the beneficiary survey was conducted by home visit using a questionnaire, it was not possible to conduct a survey to farmers who were absent due to migrant work etc., and taking a sample in perfect random manner was not possible. Of the respondents, 95% were men, and 5% were women. By the age group, 1% were in their 20s, 7% were in their 30s, 29% were in their 40s, 52% were in their 50s and 11% were in their 60s. There was no condition set for participating in the Project, such as sex or age, however, afforestation requires physical labor, and majority of the participants were men.

[29] Based on the afforestation area of the farmers, the answers of the beneficiary survey were analyzed by classifying the groups of small-scale farmers with 10 ha or less, and of large-scale farmers with over 10 ha. The total valid responses were 199, consisted of 94 small-scale farmers and 105 large-scale farmers.

Runan County, Neixiang County).

Hill/Mountain: Protection forests and economic forests are built on steep slopes in the mountains where natural conditions are especially severe. (a) Protection Forest (Pine, Black Locust, Sawtooth Oak, Chinese Arborvitae etc.) were built to prevent soil runoff from the steep slopes, (b) Economic forest (Walnuts, Oil-tea Camellia, Tea) were built on slopes which had comparatively better conditions. The growth status and the maintenance of the economic forests[30] were good. Meanwhile, in the protection forests, due to feeding damage caused by wild animals, farmers were forced to repeat supplemental plantation until the trees grew to a certain height (Luoshan County, Lingbao City, Jiyuan City).

Plain：Windbreak Forest for Agricultural Land (Lankao County)

Mountain：Protection Forest Damaged by Animal Feeding (Lingbao City)

2) Mountain Closure

Two methods were adopted according to the purposes. (a) In order to improve the quality of the forest, the natural shrubbery forest was blocked to grow, and arbores (mixed forest of broad-leaf and needle-leafed trees) was encouraged to grow (Luoshan County). While the forest density remained at 0.9 before and after the closure, arbors were encouraged to grow by the closure as expected. (b) In order to improve the coverage ratio, forest nursing was implemented. Wide-leaved trees were planted in the shrubbery forest where forest density was around 0.2, and the area was closed in order to prevent damage by livestock. By these being done, the forest density improved to 0.8 (including arbores 0.5, shrubbery 0.3) and growth of shrubbery was also promoted. Thus expected effects appeared (Jiyuan City).

3) Middle-Young Forest Tending

The method was applied to promote the growth of poor quality shrubbery forests by weeding, pruning, and pest and disease control (Neixian County, Jiyuan City). The Project implemented

[30] Economic forests were built in areas which had comparatively better natural conditions. The tree species selected were those which were not susceptible to feeding damage. Thus supplemental planting due to feeding damage was not required.

middle-young forest tending in a forest of locust trees since 2009 (Lingbao City). In comparison with the forest without tending, the trees in the forest provided under the project grew as follows: the average height was larger by 27.7%; breast diameter by 30.5%; and accumulation amount by 92.2%. The effect of the project was manifested.

Mountain Closure forest which Quality Improved (Luoshan County)

Middle-Young Forest Tending (also closed for preservation: Jiyuan City)

Issues on Afforestation Model Preparation and Implementation:

The following issues should have been considered although the growing status of forests was generally good. In Henan Province, the climate and land conditions are rich in diversity. However, only 17 types of afforestation models were prepared for the Project. The mixing ratio of trees at planting, seedling grade, seedling density, ground leveling type, size of planting hole were recorded for each model, yet no graphic planting charts for each tree species were attached. It caused forestry design variation despite the same model among the participants. Each model had choices of tree species, but because the choice was entrusted to the farmers, there was a tendency that tree species with high selling price were chosen. As a consequence, economic aspect was prioritized over the conditions such as environment or characteristic of the land for afforestation.

(5) Forest Stock Volume

The average forest stock volume of the Project sites is shown in Table 9. The target figures was 53.0 m^3/ha while the actual result was 68.93 m^3/ha. Thus the target was attained.

Table 9: Forest Stock Volume

	Baseline	Target	Actual
	Appraisal (2004)	Completion Year (2011)	Completion Year (2015[31])
Henan Province	31.1 ㎥/ha	N/A	43.33 ㎥/ha
Project Implementation Counties	38.0 ㎥/ha	N/A	55.98 ㎥/ha
Project Sites	**38.0 ㎥/ha**	**53.0 ㎥/ha**	**68.93 ㎥/ha**

Source: material provided by Henan Provincial Department of Forestry Project Office

[31] The Project completion year is 2012. However, because the forest stock volume is a value measured every five years, the neighboring 2015 result is used.

3.3.2 Qualitative Effects (Other Effects)

At the time of appraisal, the expected qualitative effect of the Project was “mitigation of damage caused by strong wind, restoration of multi-function of forest, and improvement of the living environment of residents.” Because it corresponds to the impact level, it is mentioned in the “3.4 Impacts” section.

The targets of the artificial afforestation area, the forest coverage ratio, the survival /preservation rate, and the forest stock volume were achieved, and according to the field survey, the growth status of the forests was confirmed generally as expected. Furthermore, the forests provided by the Project accounted for 13% of the afforestation, which was conducted in Henan Province during the same period as the Project. It shows that the project contributed to the improvement of forest coverage ratio and forest stock volume in the province. Therefore, the effectiveness is well-observed.

3.4 Impacts

At the time of appraisal, according to the Project objective, “contribution to mitigating damages by natural disasters such as floods and sandstorms in 71 counties of Henan Province and improving the living environment” was set as the expected impact. Additionally, indirect effects such as reduction of soil runoff and suppression of strong wind etc. were also classified as the impact for this evaluation.

3.4.1 Intended Impacts

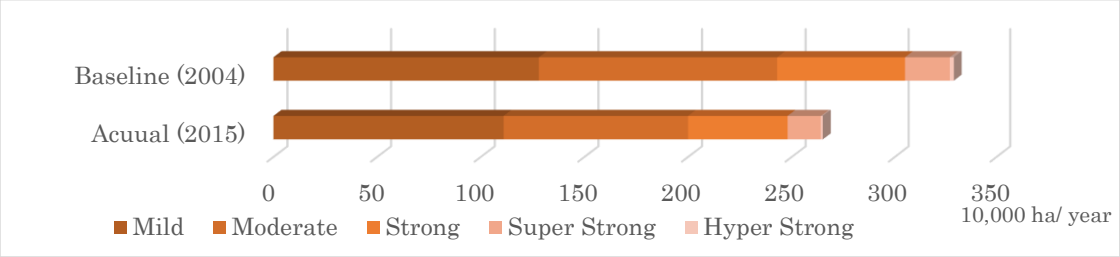
(1) Contribution in a Reduction of Soil Runoff

To verify the effect of this aspect, a total area of soil runoff in the Project implementation counties, and a total amount of economic loss were set as indicators. The targets of both indicators in 2015 were achieved (Table 10). Additionally, a bar graph (Figure 2), which classified the total area of soil runoff in the Project implementation counties according to the degree of soil runoff shows that the proportion of soil runoff whose strength level is strong or more reduced. It indicated that level of runoff was reduced. However, since external factors such as weather conditions strongly influence the damage caused by such natural disasters, the clear trend by effects of afforestation was unknown.

Table 10: Total Area of Soil Runoff and Economic Loss Caused by Flood in the Project Implementation Counties

	Baseline (2004)	Target Completion Year (2011)	Actual Completion Year (2015[32])
Total Area of Soil Runoff (ha/year)	3,283,638	3,000,000	2,657,367
Economic Loss Caused by Flood (million Chinese yuan/year)	8,962	7,618	7,429

Source: material provided by Henan Provincial Department of Forestry Project Office



Source: material provided by Henan Provincial Department of Forestry Project Office

Figure 2: Total Area of Soil Runoff in the Project Implementation Counties by the Level of Spilling

(2) The Project's Contribution to Mitigating Soil Erosion

An area of 660,900 ha was less eroded in 2012, compared with that in 2003 (Table 11). Afforestation accounted for 70% (

Table 12) of the soil erosion control measures in the province. Thus it could be assumed that afforestation reduced erosion in 462,600 ha, which was 70% of the total erosion area reduced. Furthermore, since the afforestation area of the Project was about 13% of the total afforested area in the province (Table 13), it could be assumed that the Project was effective to deter 60,000 ha, which was about 9% of the erosion area in the province, therefore the Project contributed greatly to mitigating soil erosion in the province.

Table 11: Soil Erosion Area in Henan Province

	2003	2012	Difference
Soil Erosion Area (ha)	3,007,300	2,346,400	△660,900

Source: data in 2003 refer to "2003 Bulletin of the National Census for Examination of Soil and Water Conservation." Source of the 2012's data referred is" Bulletin of the First National Census for Soil and Water Conservation (May 29, 2013)"

Table 12: Soil Erosion Control Measure and the Area in Henan Province

Measurement	Area (ha)	Ratio
Engineering Work	8,904,600	29%
Afforestation	**21,691,400**	**70%**
Other Measurement	423,500	1%
Total	31,019,500	100%

Source: Provincial result refer to" Bulletin of the First National Census for Soil and Water Conservation (May 29, 2013)"

[32] The Project completion year was 2012. However, because the stock volume is the value measured every five years, the neighboring 2015 result was employed for the evaluation.

Table 13: Afforestation area by Province and the Project

Forest Type	Indicator	Afforestation Area by Province (2007 – 2012)	Afforestation Area of the Project (2007 – 2012)	Ratio of the Project (%)
Protection Forest	Afforestation Area（ha）	908,280	165,184	18%
Economic Forest	Afforestation Area（ha）	176,050	12,580	7%
Timber Forest	Afforestation Area（ha）	416,360	19,267	5%
Other	Afforestation Area（ha）	2,240	—	0%
Total		1,502,930	197,031	13%

Source: Afforestation Area of Henan Province referred to National Statistics Yearbook, material provided by Henan Provincial Department of Forestry Project Office for the Project's result.

(3) Contribution to Mitigating Damage by Sand Storms

The expected effect by the Project implementation was the reduction in the number of sand storm occurrences, victims, damaged houses, livestock losses, and in the amount of damage. However, indicators to show such effect were not set in the Project plan and related statistics were not taken either.

As an alternative source of information, the evaluation referred to the Henan Agricultural Science Institution's report published by Henan Provincial Department of Forestry (August 2012). As a result of the 20-year observation, it is stated on average that developing windbreak forest around farmland reduced wind speed inside the forest by 35% to 40%, and moisture evaporation by 10% on average and increased humidity by 6.3%, and moisture in soil by 6.1%. Then in the agricultural lands with protection forests, it is shown that yield of corn increased by 5.5% to 13.1%, wheat by 6.8% to 17.6%, peanuts by 4.7% to 8.4%, and cotton by 8.3% to 12.8%. In the average of all the crops, yield increased by 10%.[33]

At the Gap of the Windbreak Forest, delay in growth observed in the wheat field
(Runan County: red circle indicates the part)

In the Project, there was no such quantitative data, but in the field survey, the evaluation team observed that in the part where there was a gap in the protection forest, young wheat seedlings received strong wind and the growth delayed. It can be presumed that protection forests built by the Project also were effective in terms of wind breaking, moisturizing the farm lands, and also contributed in increasing in yield.

[33] It was written in the report that the comparative data was taken in the same forest farm under the same conditions except with/without protection forest.

3.4.2 Impact on Improvement of Living Environment

(1) Beneficiary Survey on the Economical Effect[34]

1) Ratio of Afforestation Area by Forest Type

The average plantation area per a farmer by small-scale farmers was 3.8 ha, and timber forests and economic forests, which emphasized income from timbers and forest products, accounted for 55% of the area. The average plantation area of large-scale farmers was 44.8 ha, and the area of protection forests and mountain closure, which emphasize ecological effects, made up the majority, 85% of the area.

Table 14: Afforestation Area by Forest Type

	Protection Forest	Mountain Closure	Timber Forest	Economic Forest	Average Area
Small-scale Farmers	42%	3%	27%	28%	3.8 ha
Large-scale Farmers	66%	19%	11%	4%	44.8 ha

Source: Beneficiary Survey

2) Changes in Net Revenue from Afforestation

Comparing a change in net revenue before the Project (2006) and after implementation, 58 small-scale farmers (62%) and 39 large-scale farmers (37%) answered that net revenue from afforestation increased. The same change in the balance after deduction of maintenance expenses etc. from the income was compared. Then the average net revenue of small-scale farmers doubled from 5,459 Chinese yuan of before the implementation to 12,361 Chinese yuan due to the sales of the products from economic forests and thinning cut. Meanwhile, the average net revenue of large-scale farmer resulted in red because maintenance expenses increased more than the income after the implementation of the Project. For large-scale farmers, only 15% of the afforestation area is composed of timber and economic forests, and they had heavy burden of maintenance cost from protection forests and mountain closure forests especially in the mountain areas. Also, at the time of the field survey, timbers, which were expected to be a large revenue source, were still premature for logging. Thus, it will take more time until clear trends on net revenue appears.

[34] According to the executing agency, the expected effects by the Project were improvement in the livelihood of small-scale farmers and contribution to ecological effect by larger-scale farmers and forestry farms. Thus the beneficiary survey was compiled by dividing the responses into small-scale farmers (afforestation area 10 ha or less), and large-scale farmers (more than 10 ha).

Table 15: Changes in Net Income from Afforestation

	Small-scale Farmer 94 households	Large-scale Farmer 105 households	Forest Farm 7 locations
Income increased significantly.	8 (9%)	12 (11%)	0 (0%)
Income increased in some extent.	50(53%)	27 (26%)	6 (86%)
No change.	20 (21%)	3 (3%)	0 (0%)
Income did not increased much.	4 (4%)	15 (14%)	1 (14%)
Income did not increased at all.	1 (1%)	2 (2%)	0 (0%)
Not answered	11 (12%)	46 (44%)	0 (0%)

Source: Beneficiary Survey

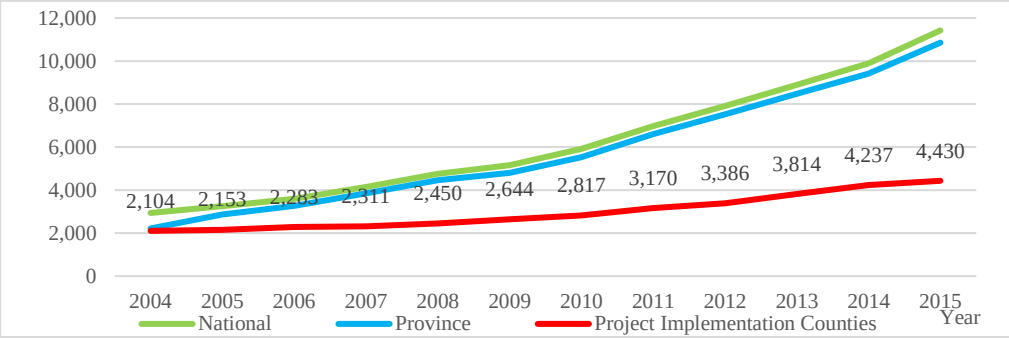
3) Survey on the Management of State-Owned Forest Farms

In addition to the beneficiary survey, a questionnaire survey to the managers of seven state-owned forests farms was conducted to see the changes in management status. All the managers in the farms answered to the questions regarding management of the farm, income of the staff, employment opportunities "improved somehow" by the Project implementation. However, one of the farm managers answered that they were facing difficulty in repayment because they built mainly protection forests, and they were not making revenue for covering the maintenance expenses. Currently, the government has been taking over the repayment.

(2) Average Income of the Farmers

The average annual income of the farmers in the project implementation counties was expected to be increased from 2,104 Chinese yuan in 2004 to 2,600 Chinese yuan in 2010. The target was achieved ahead of the schedule in 2009 (2,644 Chinese yuan), but because income may include other sources such as agriculture and migrant work besides afforestation, thus the degree of the Project's contribution was unknown. Also at the time of planning, afforestation labor fee was 28 Chinese yuan/person/day. Whereas, according to the interviews at the field survey, the fee was doubled to 50 - 60 Chinese yuan/person/day in 2008 - 2009. At the time of ex-post evaluation (2016), the fee was significantly increased to 100 - 120 Chinese yuan/person/day. Moreover, while the expenses for forest maintenance and materials etc. were also increasing due to the rise in commodity prices, the time was too early to expect the main income from forests obtained from the timbers. Therefore, it was difficult to conclude that the effect of the Project appeared at this point.

In addition, when comparing the average annual income of farmers in Henan Province with that in China, income of farmers in Henan Province was 72% of the national and 55% of the provincial average income in 2004. The disparity tended to expand. In 2009 the Project's average income was 51% of the national income and 55% of the provincial income. In 2015 the Project' average income became 39% of the national income, and 41% of the provincial income.



Source: National and Henan Province's data referred to National Statistics Yearbook, material provided by Henan Provincial Department of Forestry Project Office for Project Implementation Counties.

Figure 3: Changes of Farmers' Annual Income (2004-2015)

3.4.3 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

At the time of appraisal, because the Project was to contribute to improvement of the natural environment by implementing afforestation of native species where soil runoff and flood damage occurred, unfavorable impact on the natural environment was assumed to be minimized. According to an interview with the executing agency and answers from the beneficiary survey, by the implementation of the Project, no negative impact on the natural environment was confirmed.

(2) Land Acquisition and Resettlement

Because the afforestation area used in the Project were lands where the participants had ownership or borrowed from villages or residents with rental fees, therefore no land acquisition or resettlement of residents occurred. In the field survey, the evaluator confirmed that contracts were exchanged for lease of usage rights, and appropriate fee was paid according to the market price at the time of contracts.

(3) Unintended Positive/Negative Impact

Regarding the impact on the poor by implementation of the Project afforestation, the executing agency and the field survey cited the following:

(a) Afforestation project was implemented in the mountain areas which had a large population of the poor. In the areas, forest protection and ecological improvement were delayed.
(b) Employment opportunities for afforestation and nursing labor were created.
(c) Forest protection workers were hired for protection forests maintenance (The Forestry Department pays salary 1,500 - 2,000 Chinese yuan per month).

Considering the poor, the Project scheduled payment for the participants earlier. There were no special considerations for socially vulnerable people and women, but according to the interviews in the field survey, there was no case where poor, women, or socially vulnerable people suffered from detrimental treatment.

Economic Forest of Yabukita Tea (Luoshan County)

Among the economic forests, there was a Yabukita tea forest, where the species introduced from Japan were used. A Forestry Bureau staff who visited Japan for the Project's overseas training proposed the species. The species yields more because not only tea leaves but also branches can be used for tea[35]. Since there were few domestic competitors and the sales was also good, the forest owner built a local production factory. This tea forest provided employment opportunities for 1,000 households of farmers in the surrounding area with employment opportunities. For tea picking which required manual work, many elderly people and women were employed.

The targets set at the time of appraisal in the area of soil runoff and the economic loss due to soil runoff were attained. However, as the data was strongly affected by climatic influences, the degree of afforestation effects could not be measured. Meanwhile, according to the alternative data, afforestation provided by the Project is presumed to have prevented 9% of soil erosion in the province. Although there were no data regarding the prevention of sand storms available for the evaluation, according to the alternative data provided by the agricultural section proved that protection forests were effective in preventing winds, in moisturizing fields, and in increasing yields. Thus it can be presumed that the protection forests of the Project also contributed to suppressing strong winds.

Although the average income of farmers exceeded the target set at the time of appraisal, the degree of the Project's direct contribution was unknown. Analyzing the result of the beneficiary survey on the change in net income due to afforestation and on the management of the forest farms, because the time was early for receiving full-fledged income from the timbers in the forests, there was no clear trend in the Project's effects. To sum up, while the effect on improving the living environment did not fully come into the picture yet, there was a certain effect on mitigation of natural disasters,

In summary, the Project has largely achieved its objectives. Therefore effectiveness and impact of the project are high.

[35] While the yield of normal tea leaves is 225 kg/ha, the yield of Yabukita tea is 600 kg/ha.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

(1) Executing Agency

For the implementation of the Project, "Project Office" was established within the provincial Forestry Department, which was responsible for administration of the Project, repayment of ODA loans, and coordination among the related organizations. County-level Implementation groups were responsible for supervising operation and maintenance of the forests (Forestry Bureau), and repayment services (Finance Bureau).

From the time of appraisal (2006) to the ex-post evaluation (2016), there was no major change in this organizational structure. In the structure, coordination relations among the bureaus, province, counties and townships were established, also the scope of work and the area of responsibility were clearly defined. Also, according to the project executing agency, the number of staff was sufficient.

Table 16: Number of Project Implementation group's staff of the Counties and 7 State-Owned Forest Farms (unit: persons)

	Actual at Ex-Post Evaluation (2016)					
	Project Implementation Group	Finance Bureau	Forestry Bureau	Water Conservation Bureau	Environment Protection Bureau	Township Forestry Station
Total of 68 Counties	503	150	198	78	77	849
7 State-Owned Forest Farms	41	12	17	6	6	—

Source: material provided by Henan Provincial Department of Forestry Project Office

(2) Support System for the Afforestation Participants

The engineers in the forestry stations at the township/village level have been providing supports and technical guidance for the participants in operation and maintenance of their forests. The forestry stations at the township/village monitored the status of forests, and if pruning and thinning are needed, or problems such as pest and disease happened, they contacted the farmers, and also provided countermeasure guidance. According to the interviews with the executing agency and the field survey, there was sufficient number of staff secured to conduct monthly monitoring on the township/village forests including the Project afforestation sites.

Since Henan was one of the provinces with a large number of migrating workers[36], the probability was high that farmers were absent due to migration work for two or three years

[36] Although it is difficult to grasp the exact number of migration workers, Henan Province is one of the provinces which has a large population of migration workers in China. According to the statistics published in October 2016, 10 million people, which was about 10% of the population, were on migrant work outside the province. Besides this, there were also migration within the province, especially from rural areas to urban areas.

after new plantation, when the forests did not need nursing. Thus, the monitoring by township/village forestry stations have been taking an important role in forest maintenance.

As mentioned above, the organizational structure of the executing agency was established with the collaboration among the provincial, county and township/village levels, also forestry stations were providing monitoring and technical supports in the afforested areas, thus no problem was found in the executing agency's operation and maintenance system.

3.5.2 Technical Aspects of Operation and Maintenance

(1) Operation and Maintenance Technique of the Forestry Department

To become an engineer at the forestry department, the executing agency of afforestation project, a degree higher than university, experiences in agriculture or forestry engagement, and knowledge on laws related to forestry were required. Also, to become an engineer of county-level, experiences in forestry project related to new species and technology, and in forestry design were required. Even after being employed, the engineers were required to participate in trainings in the fields of their responsibility. In fiscal 2016, 89 kinds of trainings including forestry related laws, forest designing, fund management, fire/insect prevention, and ecological environment protection were provided for 11,408 staff members.

(2) Technical Guidance for the Afforestation Participants

Technical guidance for the forest farms was provided by the county Forestry Bureaus, and technical guidance for the farmers was carried out by township/village forestry station engineers alongside the monthly monitoring.

According to the beneficiary survey, 198 farmers (99%) participated in the technical training, and 92 small farmers (98%) and 83 large farmers (79%) received on-site technical guidance. Among the subjects, afforestation techniques, handling seedling, pest and disease control, and using fertilizers were accredited the effectiveness. Meanwhile, because the guidance was mostly provided at the afforestation time, the answer saying that the sales of forest products was effective remained less than 10%. In the future, such guidance and supports will be needed again when the time comes for logging/selling the timbers which are to be their major revenue source.

Table 17: Training Subjects that Beneficiaries Answered Effective

Effects by guidance（multiple answers allowed）	Small Farmers	Large Farmers
Afforestation technique improved	100%	91%
Seedling and plants handled appropriately	87%	76%
Prevented and cured forest from pest and disease	87%	72%
Fertilizer used appropriately	88%	58%
Managed forest appropriately	53%	45%
Managed funds appropriately	41%	36%
Motivation for afforestation rose.	65%	25%
Sold products and thinning cut appropriately	8%	5%

Source: Beneficiary Survey

The executing agency obtained qualification standards of their engineers, and the technical level was maintained by trainings. Since the participants' forests have been monitored and technical guidance has been continuously provided, the sustainability of technical aspect of operation and maintenance is to be secured.

3.5.3 Financial Aspects of Operation and Maintenance

(1) Finance of the Executing Agency.

The annual budget of the forestry departments in Henan Province is shown in Table 18 below. The budget increases year by year, and in 2015 the secured amount reached to 10 times or more than the budget in 2006. Since the Province was a target area for forestry-related priority projects at the national level, the national budget based on the "Henan Province Afforestation and Greening Project (2011-2020)" and the Forestry Development Five-Year Plans was committed. Data regarding on the budget was not provided. However according to the executing agency, the forestry bureau has budgetary frames for artificial afforestation, pest and disease control, fire and theft prevention, nursing, and sufficient amount for each has been allocated.

Table 18: Annual Budget for Forestry and the Sources (unit: ten thousand Chinese yuan)

	Annual Budget	National Budget	Domestic Loans	Bonds	Foreign Investment	Self - raising	Other Funds
2006	**107,531**	86,443	12,203	0	2,953	3,612	2,320
2007	**104,084**	92,049	5,133	0	5,820	481	601
2008	**138,904**	97,634	16,950	0	3,946	3,999	16,375
2009	**728,770**	202,708	153,956	0	15,000	224,600	132,506
2010	**951,927**	157,014	212,530	0	12,383	256,000	314,000
2011	**974,898**	297,098	213,000	0	4,900	249,900	210,000
2012	**976,351**	159,521	230,000	0	1,100	337,260	248,470
2013	**1,019,382**	110,350	310,000	0	3,800	430,000	165,232
2014	**1,102,935**	279,613	360,000	0	3,322	460,000	0
2015	**1,239,647**	766,900	109,600	0	47	363,100	0

Source: National Statistics Yearbook

(2) Finance of the Afforestation Participants

At the time of ex-post evaluation (2016), income was gained from forest products in economic forests, and thinning cuts of timber and protection forests. It was too early to cut timbers, so the participants supplemented the maintenance expenses by other incomes such as agriculture if they are deficient. However in the future, income from the timber was expected to exceed the maintenance expenses.

For example, in the forest of Poplar, six years after afforestation, 9,000 Chinese yuan/ha can be gained by thinning cut, and in about 15 years, 100 thousand Chinese yuan/ha can be earned from the sale of timbers. Even after deducting the maintenance cost of 85,000 Chinese yuan/ha, sufficient income can be expected from afforestation. Until the trees grow to a size for timbers to be shipped, it takes about 15 to 20 years for poplar and 30 years for needle-leaved tree, thus from the time of ex-post evaluation, about 5 to 20 more years will be needed until full earnings are to be obtained.

According to the beneficiary survey, regarding the maintenance of the forests at the time of the ex-post evaluation (2016), the shortage of the maintenance expenses for the protection forest of the mountainous areas was cited as a problem. As a measure for the insufficiency, the Henan Province Forestry Department expanded designation of ecological protection forests and subsidies, which included the forests arranged by the Project. In 2016, the provincial government allocated 248 million Chinese yuan for 1.29 million ha to national public benefit forests, and 58 million Chinese yuan to 320,000 ha of provincial public benefit forests as the maintenance expenses. Also, subsidies for middle-young forests tending expanded, and 424 million Chinese yuan for 140,000 ha were allocated in 2016. According to the executing agency, subsidies were to be extended to the protection forest and mountain closure forest arranged by the Project.

(3) Repayment Status of Borrowing[37]

At the time of ex-post evaluation, repayment of some contracts began. According to the executing agency, repayment has been smoothly done, and no problem occurred at the time of the ex-post evaluation. In the interviews conducted in the field survey, there were some cases of repayment delay[38], but the majority has been repaying smoothly.

[37] The farmers who participated in the Project signed two contracts: one was with the government of the township/village which was for afforestation type and area; and the other contract was for loans for expenses such as afforestation materials. Forestry farms signed a contract with the county forestry bureau for afforestation and loan. The interest rate of the loan was uniformly 0.75% on a Chinese yuan basis, and the borrowing period and the grace period were decided by consultation between the township/village government and farmers depending on the tree species planted.

[38] The counties had been temporarily advancing the repayment in a case that the contract needed to be handed over to the family due to the death of the borrower (1 household), and the cases (4 households) that the borrowers can not be reached because of the absence for migrant work.

Henan Province has been implementing several national priority projects. Therefore sufficient amount of nursing expenses to maintain the Projects' forests was allocated. In addition, participants in this project were expected to earn income that will exceed expenses when the forests grow. Meanwhile, regarding the protection forests and mountain closure forests where income cannot be expected, the provincial government has been gradually expanding the subsidies to support the expenses. Based on the above, financial sustainability was expected to be secured.

3.5.4 Current Status of Operation and Maintenance

In this section, the status of the forests confirmed through the field survey and questionnaires, and perception about the current status of the forest by the beneficiary survey are to be analyzed, in order to determine whether the forests by the Project are to be sustainably operated and maintained.

(1) Condition of the Forests

According to the questionnaire conducted through the executing agency, all the counties recognized that their forests were in good condition. Moreover, the evaluation team visited the Project sites in the cities/counties and the forest farms during the field survey, and confirmed the condition of the forests were largely good at the time of ex-post evaluation.

Regarding the preservation rate at the time of ex-post evaluation (2016), the averages of the beneficiary survey are shown in Table 19. All the average preservation rate of protection forest, economic forest and timber forest exceeded 80%. Thus it can be stated that the condition of the forests were largely good. Meanwhile, the preservation rate of two small-scale farmers' protection forests (2%), two large-scale farmer's timber forests (2%) and 12 large farmers' protection forests (11%) were lower than 80%.

Table 19: Preservation Rate at the Time of Ex-Post Evaluation (2016)

	Small-scale Farmers			Large-scale Farmers		
	Protection Forest	Economic Forest	Timber Forest	Protection Forest	Economic Forest	Timber Forest
Preservation Rate	87.6%	87.5%	84.1%	86.6%	86.7%	82.0%

Source: Beneficiary Survey

Regarding the condition of the forest, 85 small-scale farmers (90%) and 87 large-scale farmers (85%) answered that their forests were in good condition. No farmer answered that there were many problems in their forests. However, seven small-scale farmers (7%) and 18 large-scale farmers (17%) responded that there were some problems. The main reasons cited were problems in pest and diseases (18 small-scale farmers, 43 large-scale farmers), and problems in survival /preservation rate (15 small-scale farmers, 27 large-scale farmers).

(2) Operation and Maintenance Status of Forests

Regarding the operation and maintenance status[39] of the forests, the province had a nursing and protection plan, and the engineers of the forestry stations have been conducting a monthly forest monitoring on the pest and disease control during the growing and winterization time, fire prevention, damage by livestock, theft, and the status of the forests. Regarding state-owned forest farms and mountain close forests, forest protection workers and the farms' staff were conducting monitoring twice in a month.

Regarding the forest operation and management status at the time of ex-post evaluation (2016), 79 small-scale farmers (84%) and 70 large-scale farmers (67%) answered in the beneficiary survey that their forests were operated and maintained well. No farmer answered that there were many problems. However, 12 small-scale farmers (13%) and 34 large-scale farmers (32%) responded that there were some problems. The main reasons were cited as shortage of maintenance budget (33 small-scale farmers, 29 large-scale farmers), and shortage of manpower (11 small-scale farmers, 30 large-scale farmers).

(3) Operation and Maintenance Status of Equipment

According to the executing agency, the operation and maintenance status of the equipment purchased by the Project[40] has been good. Some signboards were removed because the forests were improved to the state that the closure was unnecessary.

The 70 patrol vehicles were allocated to the forestry bureau of each county as a property of the bureau, but due to administration reforms started in 2015, the bureaus were requested to return some of the vehicles. According to the executing agency, although the number of vehicles returned was unknown, rental vehicles were appropriately allocated, and there was no obstacle to their forestry work such as patrolling.

The status of operation and maintenance was generally good. In some protection forests, where revenue could not be expected because ecological effects were emphasized, maintenance expenses were found to be insufficient. However, expenditure on protection forest maintenance has been covered by other income sources, and subsides for protection forests' maintenance have been expanding. Thus, sustainability of the Project's effects is expected to be secured.

As mentioned above, the operation and maintenance structure of the Project was established, and no major problems were found in the technical, financial aspects, and status

[39] Through the field survey, existence of manuals, patrol records, and liaison structure at the time of emergency at forestry stations and state-owned forest farms were confirmed.

[40] Among the equipment procured, as pumps, spreaders and monitoring buildings did not exist in the Project sites the evaluator visited in the field survey. Alternatively confirmation was done by photographs.

of the operation and maintenance, therefore sustainability of the project is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The Project aims to enrich forest resources by afforestation in Henan Province, thereby contributing to suppression of soil erosion in mountainous areas and strong winds in plains, mitigating damage of natural disasters such as floods and sandstorms in the area, and improving the living environment.

The Project was prompted by the increase in importance of afforestation because of the escalation of natural disasters in the Yellow River and the Yangtze River basin areas at the time of appraisal. The Project's relevance is high because its aim is consistent with the Chinese Government's development policies, development needs and the aid policy of Japan.

The targets on the enrichment of forest resources such as artificial afforestation area, forest coverage ratio, survival/preservation rate, and stock volume were achieved. The Project implementation area was equivalent to 13% of the area afforested in the province during the same period; also the project contributed to improving the forest coverage ratio and stock volume in the province.

Regarding the improvement of life, although the Project's economic effect from afforestation are has not yet been developed, the Project yielded certain effects on reducing natural disasters such as deterrence of approximately 9% of the soil erosion and suppression of strong winds. Thus the effectiveness and impact of this project are high. With regard to the efficiency, the project cost was within the planned limit, though the project period exceeded the plan due to the extension of afforestation period. Thus the efficiency of the Project is fair.

At the time of ex-post evaluation, there was no change in the structure of the executing agency, and a structure to support forest management has been established. Because the central government allocated budget for national priority projects, funds for operation and maintenance including nursing and pest and disease control were secured in the province. The shortage was found in the maintenance costs of protection forests among some farmers and forest farms at the time of ex-post evaluation. However, the provincial forestry department had a policy to increase subsidy for the maintenance of protection forests for ecological purpose, thus in the medium term, the shortfall was expected to be resolved. Also, a few problems were observed in technical aspects, and the maintenance status, therefore the sustainability of the Project is fair.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

In the protection forests in the mountains where ecological effects were emphasized, the

maintenance expenses were burden on the farmers and forest farms because the economic effects by the forest products etc. were small. It can not be denied if the maintenance expenses are insufficient, there are possibilities that necessary forest maintenance will not be carried out, and the forests may end up to be deteriorated. The Province has been expanding designation of ecological forests and provision of maintenance expenses. Especially for the protection forests in the mountainous area in severe natural conditions, immediate measures such as subsides for nursing etc.is desired.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Presenting Convenient Afforestation Models to Farmers

Henan Province is rich in diversity of lands. It has mountains, plains, and various conditions of lands. The Project provided only 17 types in a table including afforestation model including protection, economic, and timber forests. Because the models were not prepared for each tree species, and the materials were not user friendly because there were no charts indicating planting methods. As the result, it caused variations in planting density. At the time of planning and also during the Project implementation, the Forestry Department should have prepared materials considering the convenience of farmers, incorporate the opinions of engineers at the county and township/village levels.

Selecting Tree Species with Future Potential

Farmers tended to select tree species with high selling prices because selection of tree species planted in their forest was left up to the autonomy of the farmers. Poplar in timber forests, and walnuts in economic forests were the popular selection. Similar tendency were observed in afforestation projects implemented in the state. The forest products of popular species have been oversupplied, which have been leading to the price decline. It seems that nature and land conditions were not sufficiently examined by farmers at the time of selection. For example, feeding damage by rabbits etc. occurred in protection forests in mountains, but it would have been prevented if the farmers had planted coniferous trees such as pine trees. The executing agency should have provided materials that allow farmers to understand the characteristic of the tree species so that they can choose species by taking into consideration the natural conditions, the characteristics of the land, and the afforestation effects of both ecological and economic aspects from the medium to long term. Also, the executing agency should have asked farmers to select tree species after seeking their understanding in trainings and local technical guidance.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
Afforestation Area	**194,190 ha**	**197,031 ha**
Protection Forest	163,610ha	165,184 ha
Economic Forest	11,880 ha	12,580 ha
Timber Forest	18,700 ha	19,267 ha
Procurement of Material and Equipment		
Signboard	2,202 locations	696 locations
Pump	161 sets	141 sets
Pesticide Spreader	172 sets	162 sets
Building for Monitoring	480 locations	251 locations
Patrol Vehicle	71 sets	70 sets
Overseas Training		
Staff of Forestry Related Departments	20 persons 5 times Total 80 persons	5 times Total 107 persons
Training in China		
Provincial Leve	N/A	5,084 persons
County Level	N/A	25,245 persons
2. Project Period	June 2006 – September 2011 (64 months)	June 2006 – August 2012 (75 months)
3. Project Cost		
Amount Paid in Foreign Currency	480 million yen	258 million yen
Amount Paid in Local Currency	10,964 million yen (800 million Chinese yuan)	10,708 million yen (764.4 million Chinese yuan)
Total	11,444 million yen	10,966 million yen
ODA Loan Portion	7,434 million yen	7,218 million yen
Exchange Rate	1 Chinese yuan = 13.7 yen (As of September 2005)	1 Chinese yuan=14.23yen (average of actual exchange rate 2007-2014)
4. Final Disbursement	December 2014	

People's Republic of China

FY 2016 Ex-Post Evaluation of Japanese ODA Loan Project

"Shanxi Xilongchi Pumped Storage Power Station Project"

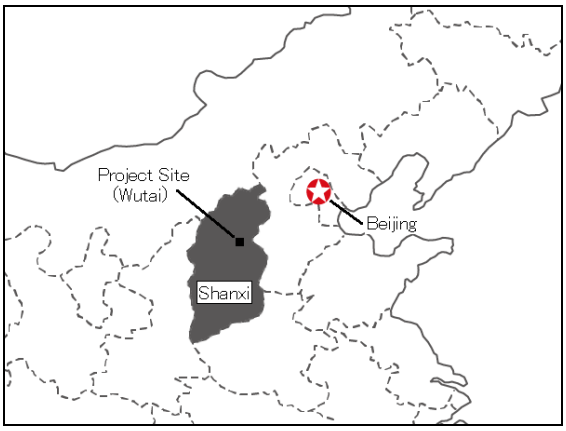
External Evaluator: Toshihiro Nishino, International Development Center of Japan Inc.

0. Summary

The objective of the Project was to improve the peak demand handling capability and the reliability as well as economy of power system operation by constructing a pumped storage power station in Shanxi Province, thereby contributing to the containment of the emission volume of air pollutants. The Project was in line with the electric power and environmental policies of the Government of China as well as the government of the target province, development needs of China to improve air pollution and to increase the stability and economy of power supply and Japan's ODA policy. As such, the relevance of the Project is high. The efficiency of the Project is fair because of the fact that although the project cost was within the planned cost, the project period exceeded the plan. The expected role of the Project (Xilongchi Power Station) has changed as a result of the changing circumstances of the electric power industry in Shanxi Province. In response to such changes, the Xilongchi Power Station currently performs its principal roles of "responding to the peak demand" and "adjusting the power demand and supply for the development of alternative energies (facilitation of air pollution prevention) without fail and various indicators had mostly achieved the target values by the time of this ex-post evaluation. Sufficient positive effects are observed with the anticipated improvement of the stability and economy of power supply. A certain effect of the Project is also confirmed in relation to ① development of the socioeconomy and improvement of poverty in local communities and ② facilitation of the further introduction of Japanese technologies to China. In contrast, the target values set at the time of appraisal were substantially undershot for all indicators of the effectiveness and impacts two years after project completion. In consideration of the foregoing, the effectiveness and impact of the Project are fair. The sustainability of the Project poses no problems in terms of the institutional, technical and financial aspects. As good operation and maintenance conditions were confirmed for the facilities and equipment, the sustainability of the Project is high.

In light of the above, the Project is evaluated as satisfactory.

1. Project Description



Project Locations

Generators

1.1 Background

At the time when the Project was conceived, the Government of China had been emphasizing the development of power sources as the driving force for high economic growth and had actively been promoting investment in the electric power industry. The remarkable results of such efforts included an increase of the installed capacity by 2.3 times (to 320,000 MW) and the power generation amount by 2.2 times (to 1.37 million GWh) in the 10-year period from 1990 to 2000. The power demand maintained its high growth exceeding the rate of economic growth, however, making it essential to further increase the installed capacity. Meanwhile, China's dependence on coal for energy supply at some 70% with a high proportion of coal-fired thermal power generation meant worsening environmental problems in urban areas.

In Shanxi Province located in North China, the development of industries and agriculture relatively lagged behind other provinces despite its rich mining and energy resources. Even though the installed capacity and annual power generation amount for the provincial power grid were 12,700 MW and 62,100 GWh respectively, 97% of the power generation amount relied on coal-fired thermal power generation with a heavy environmental load (Year 2000). The maximum gap in a year between the daily maximum load and minimum load was as large as some 2,500 MW (Year 2000) and this gap showed an increasing trend for the future. In Shanxi Province where thermal power generation had an overwhelming share, the need to adjust the power output to balance the maximum load and minimum load was dealt with by DSS (daily start and stop) of power stations and power output control operation, causing such problems as shortening of the service life of the generating facilities, lowering of the thermal efficiency, increase of the operation and maintenance cost and a further increase of the environmental load. The dust and air pollutants discharged from coal-fired thermal power stations constituted one of the largest

factors for air pollution in Shanxi Province, causing a steady increase of the environmental load.

1.2 Project Outline

The objective of the Project was to improve the peak demand handling capability and the reliability as well as economy of power system operation by constructing a pumped stored power station in Shanxi Province, thereby contributing to the prevention of air pollution through the reduction of the emission of SO_2, NOx and others and also to the containment of the emission volume of Greenhouse Gas (GHG) through the reduction of CO_2 emission.

Loan Approved Amount/Disbursed Amount	23,241 million yen/19,069 million yen	
Exchange of Notes Date/Loan Agreement Signing Date	March 2002 / March 2002	
Terms and Conditions	Interest Rate Repayment Period (Grace Period) Conditions for Procurement	0.75% 40 years (10 years) General untied (Bilateral tied for the consultant)
Borrower/Executing Agencies	The Government of People's Republic of China /State Electric Power Company (SPC)	
Project Completion	August 2011	
Main Contractors	Mitsubishi Electric Corporation (Japan)/ Hitachi Ltd. (Japan)/Toshiba Corporation (Japan)/Mitsubishi Corporation (Japan) (JV); Mitsui & Co. (Japan), Taisei Corporation (Japan), Sumitomo Corporation (Japan)	
Main Consultants	East China Investigation and Design Institute (China)/Tokyo Electric Power Services Co., Ltd. (Japan)	
Feasibility Studies, etc.	F/S by Beijing Engineering Corporation Ltd. (March, 1999)	
Related Projects	-	

2. Outline of the Evaluation Study

2.1 External Evaluator

Toshihiro Nishino, International Development Center of Japan Inc.

2.2 Duration of Evaluation Study

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

Duration of the Study: July 2016 - October 2017

Duration of the Field Study: October 16 - 29, 2016 and March 19 - 25, 2017

3. Results of the Evaluation (Overall Rating: B[1])

3.1 Relevance (Rating: ③[2])

3.1.1 Consistency with the Development Policy of China

At the time of project appraisal, the development policy of the Government of China had changed, as indicated in "the 9th Five Year Plan (1996‐2000)", from the conventional policy of stressing an increase of the power generating capacity to a policy of favoring the improvement of the energy utilization efficiency through adjustment of the configuration of power sources, further improvement and enhancement of the transmission and distribution networks, improved capacity to deal with the peak power demand through the construction of pumped storage power stations, etc. and other means, following easing of the supply-demand gap due to an increasing amount of electricity generated in China. As far as environmental consideration was concerned, the containment of harmful emissions and promotion of environmental protection through the expanded use of clean energies and the introduction of new technologies were called for. Subsequent Five Year Plans consistently emphasized environmental consideration and the efficiency supply of energy due to an increase of power generation amount. "The 13th Five Year Plan (2016‐2020)" sets out quantitative targets for various indicators, including "aggregate major pollution emission reduction" and "percentage of non-fossil energy in primary energy consumption", stressing environmental improvement and the development of hydropower generation (target for the output of pumped storage power stations to be newly constructed: 17 million kW).

In response to these national policies, the Shanxi Provincial Government has been adopting its own policies to strengthen the peak demand handling capability and to accommodate environmental consideration. "The 13th Five Year Plan for Shanxi Province (2016‐2020)" emphasizes and promotes the ① improvement of the energy utilization efficiency, ② facilitation of alternative energy development, ③ promotion of low carbon development and ④ increase of the ratio of non-fossil fuel in the energy consumption in view of the currently high level of dependency on coal-fired thermal power generation.

Accordingly, at the time of both appraisal and ex-post evaluation, the contents and objective of the Project are in line with the electric power policy of China in that "the project is an attempt to achieve an efficient energy supply and to address environmental issues through adjustment of the configuration of power sources".

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

[2] ③: High, ② Fair, ① Low

Table 1: Main Objectives of Development Plans Related to the Project

Type of Document	At the Time of Appraisal	At the Time of Ex-Post Evaluation
National Level Electric Power Policy and Development Plan	9th Five Year Plan (1996-2000) Proceeds with such policies for the purpose of adjusting the configuration of power sources as ① optimization of the configuration of power sources and improvement of power generation, transmission and distribution, ② power supply to areas of insufficient power supply and improvement of the transmission and peak demand handling capability through the construction of pumped storage power stations, etc. and ③ containment of harmful emissions and environmental protection through the introduction of new technologies.	13th Five Year Plan (2016-2020) Sets quantitative targets for "aggregate major pollutant emissions", "ratio of days of excellent air quality in cities" and "non-fossil energy (percentage of primary energy consumption)", emphasizing environmental improvement and the development of hydropower generation.
Electric Power Development Plan	10th Five Year Plan for Electric Power Industry (2001-2005) Numerical targets: ① installed capacity of newly constructed hydropower stations of 27,300 MW of which 7,400 MW is accounted for by pumped storage power generation during the plan period (the actual figures in the five-year period were 12,700 MW and 1,100 MW respectively) and ② increased share of thermal power generation among power stations of which the rated output is 500 MW or more to some 50% in 2005 (from 38% in 2000).	13th Five Year Plan for the Electric Power Industry (2016-2020) Priority plans: ① to establish an efficient and modern energy system which is low carbon, clean and safe, ② to increase the ratio of non-fossil energy while facilitating the clean and efficient use of fossil fuels and ③ to promote the development of renewable energies. Numerical target: construction of additional pumped storage power stations with a total installed capacity of 17 million kW to reach 40 million kW. Energy Development Strategy Action Plan (2014 - 2020) of the State Council Four strategies: ①Adhere to an "economical, clean and safe" strategy, ② Promote domestic strategy, ③ Realize green and low carbon society and ④ Promote innovation. Numerical targets: ① proportion of non-fossil fuels in primary energy consumption of 15% in 2020 (hydroelectric installed capacity in 2020 of approx. 340 million kW), ② newly installed capacity of operating hydroelectric power stations of approx. 40 million kW with 60 million kW or more installed capacity of power stations under construction ③ 40 million kW of renewable energies in three northern areas (Northwest, North and Northeast).
Provincial Level Development Plan		13th Five Year Plan for Shanxi Province (2016-2020) Emphasizes improvement of the efficiency of energy use, facilitation of the development of alternative energies, promotion of low carbon development and improved ratio of non-fossil fuels.

Source: Documents provided by JICA and plan documents

3.1.2 Consistency with the Development Needs of China

At the time of project appraisal, Shanxi Province almost entirely depended on coal-fired thermal power generation (accounting for 97% of the power generation amount) which was characterized by a large environmental load. In addition, there was a large gap between the maximum daily load and minimum daily load and this gap was predicted to increase (the maximum gap in a year between the maximum daily load and minimum daily load in 2000 was 2,500 MW which was predicted to increase to 4,600 MW in 2010). Because of this, Shanxi Province faced major problems in terms of the reliability and economy of power system operation and environmental load. While this large gap between the maximum and minimum load was handled by DSS and output adjustment of thermal power stations, such mode of operation caused a shorter service life, reduced thermal efficiency and increased maintenance cost of the generating facilities and a further increase of the environmental load. There was a highly urgent need to achieve ① improvement of the operating conditions of coal-fired thermal power stations, ② containment of fuel consumption of coal and oil, ③ prolongation of the service life of thermal power stations, ④ improvement of the reliability of power system operation and the quality of supplied electricity and ⑤ prevention of air pollution and containment of GHG emission. As such, it is safe to say that the Project was relevant to the development needs of China.

Table 2: Historical Changes of Basic Electric Indicators in Shanxi Province

	2000	2009	2011	2013	2015	2016
Installed capacity (MW)	12,749	28,260	37,170	45,590	57,550	62,310
Coal-fired (MW)	11,771	26,590	33,655	39,700	45,550	48,840
Power generation amount (GWh)	62,087	137,050	171,000	197,400	186,100	189,900
Coal-fired (GWh)	60,475	133,950	164,250	186,800	172,600	170,300
Maximum load（MW）	7,614	19,191	21,846	24,654	22,858	24,677
Minimum load（MW）	-	11,202	12,736	14,475	12,503	12,348
Maximum daily range（MW）	2,485	4,797	5,276	6,061	5,999	6,322

Source: Documents provided by JICA and responses to the questionnaire of the executing agency.
Note: “Maximum daily range” indicates the highest value for the maximum gap between the maximum daily load and minimum daily load in the relevant year.

By the time of the ex-post evaluation, the very tight power supply and demand situation has considerably improved due to an increase of the installed capacity following the completion of new power stations and also due to the slowing down of economic growth and the growth of the power demand compared to the period up to around 2011 when the installed capacity lagged behind the rapid increase of the power demand. The capacity to deal with the peak demand has also improved due to ① narrowing of the power supply and demand gap and ② strengthening of the output adjustment function of thermal power stations following the commissioning of new power stations. Nevertheless, further enhancement of the adjustment function is still

necessary to ensure a stable power supply and, therefore, the situation where pumped storage power stations' possession of such adjustment function is highly significant remains unchanged. In recent years, the development of such alternative power sources as wind power has been promoted but the unstable power supply from these sources makes strengthening of the existing adjustment function essential to increase the amount of power generation. In other words, the smooth development of alternative energies is impossible without using the adjustment function of pumped storage power stations. Moreover, the situation of air pollution is still serious in major cities in Shanxi Province. Hydroelectric generation is seen to be an important means of contributing to the prevention of air pollution from three viewpoints: ① clean energy, ② ability to reduce the environmental load through the efficient adjustment of the power supply and demand and ③ essential for the promotion of the development of alternative energies.

3.1.3 Consistency with Japan's ODA Policy

At the time of appraisal, "Japan's Country Assistance Policy for China" (2001, MOFA), "the Medium-Term Strategy for Overseas Economic Cooperation Operations" (2002, JICA) and "the Country Assistance Strategy for China" (2002, JICA) placed priority on ① environmental conservation measures and ② measures designed to improve the standard of living and to reduce poverty in inland China, underlining the relevance of the Project to Japan's ODA policy. The assistance policy for the energy sector as indicated in the "Country Assistance Strategy" clearly spells out the priority to assist the promotion of the development of hydropower generation (pumped storage power generation, etc.) while calling for an integrated approach to take into consideration the situation of the power supply and demand, environmental consideration, capacity to transport coal, private sector investment and other issues.

The Project is highly relevant to China's development plans and development needs at the time of both appraisal and ex-post evaluation as well as to Japan's ODA policies at the time of appraisal. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The main outputs of the Project were newly constructed upper and lower regulating reservoirs, an underground power station (with four generating units), headrace and tailrace in addition to the installation of a switchyard and procured equipment. As Table 3 shows, the size of both reservoirs was increased by 10% to

20%[3] and minor adjustments were made to the range of equipment to be procured. The actual outputs were, however, generally as planned. The work contents of the consulting service were unchanged. According to the results of the interview survey with the executing agency and some relevant reference materials, changes to the planned outputs were made in accordance with the necessary procedure to respond to the needs of the Project, posing no problems.[4]

Table 3: Planned and Actual Outputs

Item	Planned (at the Time of Appraisal)	Actual
Upper regulating reservoir (effective storage capacity)	Approx.4.2 million m^3	4.6 million m^3
Lower regulating reservoir (effective storage capacity)	Approx.4.2 million m^3	4.8 million m^3
Underground power station	300MW×4 units	As planned
Headrace and tailrace	Penstock x2; branch pipe x4; tailrace x4	As planned
Switch yard	Transformer 340MVA x 4 units; 500kV outgoing system	As planned
Consulting services	Assistance for tender; review of the detailed design; assistance for work supervision	As planned
Procured equipment	Reversible pump-turbine; GIS; cables; auxiliary equipment, etc.	The quantities of monitoring equipment, steel, etc. were slightly changed due to necessary circumstances.

Source: Responses to the questionnaire of the executing agency.

Upper regulating reservoir

Lower regulating reservoir

[3] According to the executing agency, these changes were judged to be minor modifications at the detailed design stage based on the actual conditions of the Project.

[4] At the appraisal stage, the Project was considered to "require careful attention because of its scale and requirement for high (technical) standard." The interview survey with Japanese and Chinese persons involved in the Project found that no problems emerged as the actual situation surrounding the Project remained the same as originally presumed.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The actual project cost was 69,209 million yen which was within the planned cost of 77,991 million yen (89% of the planned cost) as shown in the following table. The reasons for the lower actual cost than the planned cost were ① active efforts to reduce the consulting services cost payable in local currency, ② containment of the procurement cost of electrical and mechanical equipment through an international competitive tender, ③ containment of the domestic civil engineering cost through a tender and ④ continual appreciation of the yen during the project period. As mentioned earlier, the outputs were achieved as planned. The lower project cost suggests that appropriate efforts to suppress the project cost were made.

Table 4: Planned and Actual Project Costs

Unit: million yen

	Plan (Appraisal)			Actual		
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total
Civil engineering works	2,790	28,380	31,170	2,600	25,493	28,093
Electrical and mechanical equipment	16,724	5,190	21,914	13,865	5,558	19,423
Steel structure	1,096	2,010	3,106	2,497	1,213	3,710
Consulting	214	5,865	6,079	107	920	1,027
Taxes, administration cost, etc.	0	10,740	10,740	0	16,956	16,956
Inflation	1,320	510	1,830	0	0	0
Contingency	1,097	2,055	3,152	0	0	0
Grand total	23,241	54,750	77,991	19,069	50,140	69,209

Sources: Documents provided by JICA and responses to the questionnaire of the executing agency.
Note: Planned exchange rate: 1 yuan = 15 yen (September, 2001)
Actual exchange rate: 1 yuan = 14.0 yen (mean exchange rate between 2001 and 2011)

3.2.2.2 Project Period

The actual project period of 118 months (November, 2001 to August, 2011) was much longer than the planned period of 94 months (November, 2001 to August, 2009) (126% of the planned period). The main reason for this over-run of the project period was damage caused to the No. 1 and No. 2 generators during the trial run in October, 2009 which necessitated investigation to identify the cause of the accident and subsequent replacement of the generators. After this accident, a restoration plan was prepared and a steady response was made based on the plan. Nevertheless, the project period exceeded the planned period by 24 months.

Table 5: Planned and Actual Project Periods

	Planned (Appraisal)	Actual
Loan agreement signing date	March, 2002	March, 2002
Project period	November, 2001 - August, 2009 (94 months)	November, 2001 - August, 2011 (118 months)
Preparatory work	November, 2001 - June, 2003	November, 2001 - August, 2003
Upper regulating reservoir	June, 2003 - March, 2006	December, 2003 - September, 2008
Lower regulating reservoir	February, 2003 - May, 2007	August, 2003 - September, 2010
Power station	May, 2003 - December, 2006	September, 2003 - August, 2011
Electrical machinery	January, 2004 - August, 2009	March, 2006 - July, 2009
Consulting	October, 2002 - June, 2008	March, 2003 - November, 2008
Completed trial run of No.1 unit	August, 2009	May, 2011
Completed trial run of No.2 unit	August, 2009	August, 2011
Completed trial run of No.3 unit	August, 2009	April, 2009
Completed trial run of No.4 unit	August, 2009	November, 2008

Sources: Documents provided by JICA and responses to the questionnaire of the executing agency.
Note: As part of the Project started using Chinese funding before the signing of the loan agreement, the commencement of the Project was before this signing.

3.2.3 Results of Calculations of Internal Rates of Return (Reference only)

Financial Internal Rate of Return

At the time of appraisal, only the financial internal rate of return (FIRR) was calculated. In this ex-post evaluation, the FIRR is recalculated. At the time of appraisal, the items considered to be costs were the construction cost of the Project, cost of electricity purchase for pumping, operation and maintenance cost and taxes while the revenue from the sale of electricity was considered to be the benefit. The calculated FIRR for the period of 30 years was 8.06%. The recalculated FIRR[5] at the time of ex-post evaluation using the same cost, benefit and project period assumed at the time of appraisal was -4.45%. The reasons for this negative FIRR were that ① the actual revenue from the sale of electricity significantly lowered than the planned (from 102.8 million yuan/year at the time of appraisal to approximately 45.5 million yuan/year at the time of ex-post evaluation; 44% of the revenue assumed at the time of appraisaland ② delayed completion of the Project (longer construction period than planned) which delayed the start of operation (to generate revenue). Meanwhile, the operating cost after the completion of the Project is slightly lower

[5] For recalculation of the FIRR, it was assumed that the averaged actual values for the last three years would be maintained as the benefit (revenue for the sale of electricity), costs (cost of purchased electricity and personnel cost, etc.) and taxes.

than the planned cost at the time of proposal (36.2 million yuan/year at the time of ex-post evaluation compared to 40.2 million yuan at the time of appraisal; 90% of the planned cost).

Although the project cost was within the planned cost, the project period exceeded the plan. Therefore, the efficiency of the Project is fair.

3.3 Effectiveness[6] (Rating:②)

For evaluation of the effectiveness, major changes of the environment surrounding the Project and the status of the Project were taken into full consideration.

3.3.1 Quantitative Effects (Operation and Effectiveness Indicators)

Table 6 shows the historical performance of the operation and effectiveness indicators which were set at the time of appraisal to indicate the quantitative effects of the Project.

Table 6: Historical Performance of Operation and Effectiveness Indicators

	Target	Actual						
	(2011)	2011	2012	2013	2014	2015	2016	Average between 2013 and 2016
	2 years after project completion	Year of project completion	1 year after project completion	2 years after project completion	3 years after project completion	4 years after project completion	5 years after project completion	
【Operation Indicators】								
Installed capacity（MW）	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Operating hours (generating hours/year)	4,811	1,704	148	609	1,802	2,591	4,768	2,443
Operating hours (pumping hours/year)	4,201	1,797	170	541	1,780	2,793	5,530	2,661
Operating rate (%)	91.6	29.2	2.5	10.4	30.9	44.4	81.6	33.2
Utilization factor (%)	91.6	21.7	1.8	6.5	22.9	35.4	64.3	25.4
Comprehensive circulating efficiency (%)	75	75	59	70	75	73	74	73
Unplanned stoppage hours (hours/year)	12	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
【Effectiveness Indicator】								
Annual power generation amount (GWh)	1,796	381	31	114	401	620	1,638	693

Sources: Documents provided by JICA and responses to the questionnaire of the executing agency.
Notes: ”operating rate” = (actual power generating hours) /(4 units x 4 hours x 365 days); “utilization factor” = (actual power generation amount）/(4 units x 4 hours x 300 MW x 365 days); “overall cycle efficiency” = (sending-end power generation amount”/”power consumption for pumping operation) x 100.

[6] Sub-rating for Effectiveness is to be put with consideration of Impact.

The performance of the indicators in 2013, two years after project completion and for which the target values were set at the time of appraisal, showed that while the target for installed capacity was achieved, the operating hours (generating hours) and annual power generation amount were considerably below their targets. The former was 13% of the target value (609 actual hours compared to 4,811 target hours) and the latter was 6% of the target value (114 actual GWh compared to 1,796 target GWh). As such indicators as the operating rate, utilization factor and comprehensive circulating efficiency were affected by the operating hours (generating hours) and power generation amount, their actual performance levels were low, failing to achieve the respective targets.[7] However, the actual performance of both the operating hours (generating hours) and annual power generation amount has shown a rapid recovery trend in recent years. The actual figures in 2016 representing the latest figures at the time of ex-post evaluation show that the operating hours (generating hours) achieved 99% of the target value (4,768 actual hours compared to 4,811 target hours) and the annual power generation amount achieved 91% of the target value (1,638 actual GWh compared to 1,796 target GWh). As a result, many of the quantitative indicators reached the level of roughly achieving the target.

Regarding pumped storage power stations, the operating hours (generating hours) and annual power generation amount generally tend to greatly fluctuate from one year to another[8] and it is inappropriate to evaluate the performance of a station based on a single year. As such, the present ex-post evaluation has examined the average values for the actual performance for a period of two years after project completion to the time of ex-post evaluation (from 2013 to 2016). On this basis, the operating hours (generating hours) and annual power generation amount achieved 51% of the target for the former (2,443 actual hours compared to 4,811 target hours) and 39% of the target for the latter (693 actual GWh compared to 1,796 target GWh). When compared to the performance in 2013, i.e. two years after project completion, these average figures show much improvement reflecting the recent trend of recovery but are still below the target values.

The reasons for these results are ① considerable changes of the socioeconomic environment surrounding the Project and ② significant change of the status of the Project following changes of its environment (see Table 7).

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[7] No data was obtained for unplanned stoppage hours but those in charge at the executing agency replied in an interview that the target was achieved.

[8] Taking such characteristics of pumped storage power generation into consideration, Shanxi Xilongchi Pumped Storage Power Generation Co., Ltd. (Xilongchi Pumped Storage Power Station) and Shanxi Electric Power Group Co, Ltd. (Shanxi Electric Power Company) have signed "a fixed amount contract based on the installed capacity regardless of the power generation amount" to ensure stable revenue for the former.

Table 7: Changing Roles of the Project

	2001(Time of Appraisal)	2012-14 (1-3 years after Completion)	2015-16 (Time of Ex-Post Evaluation)
Socioeconomic situation	・Tightening of power supply due to a rapid increase of power demand ・Insufficient adjustment function due to the widening of the gap between the maximum and minimum loads	・Slowdown of the increase of power demand due to sluggish economy ・Decline of the necessity for the adjustment function due to narrowing of the gap between the maximum and minimum loads	・Increasing necessity for the function to adjust the gap between the maximum and minimum loads following the improvement of the economy ・Necessity to strengthen the adjustment function following the development of alternative energies
Expected roles of the Project	・Response to the peak demand (strong need) ・Power supply source for intermediate-load to combat power shortage	・Response to the peak demand (decline of the need)	・Handling of the peak demand (increase of the need to do so) ・Adjustment of demand and supply following the development of alternative energies

Source: Prepared by the evaluator

At the time of appraisal (2001), the power supply in Shanxi Province was insufficient to meet the demand while the supply-demand adjusting capacity was poor. Because of this, it is safe to assume that the Project was expected to partly play the role of an intermediate power source in addition to boosting the capacity to deal with the peak demand.[9] At that time, the target operating hours (generating hours) was set at approximately 4.1 hours a day.[10] The above assumption is backed by ① the comparable performance of a pumped storage power station in Japan shows average daily operating hours of 0.43 to 1.57 hours in the case of Kansai Electric Power Co., Inc. (a pumped storage power station with an installed capacity of 5,060 MW and annual power generation amount of 800 - 2,900 GWh)[11] and ② in China, the actual average operating hours for pumped storage power stations are less than two hours except in 2016 as shown in Table 8 and, therefore, the target operating hours of 4.1 hours for the Xilongchi Power Station were beyond the normal operating hours to deal with the peak demand.

[9] This idea was confirmed by those in charge of the Project at the executing agency.

[10] Target annual power generation amount ÷ (installed capacity x 365 days) = 1,796,000 MWh ÷ (1,200 MW x 365 days) = 4.1 hours

[11] From the website of Kansai Electric Power Co., Inc. (http://www.kepco.co.jp/corporate/profile/data/dengen.html)

Table 8: Historical Changes of Power Generation by Pumped Storage Power Stations in China and under the Project

		2011	2012	2013	2014	2015	2016
China	Annual power generation amount (GWh)	10,900	9,300	10,700	13,200	15,800	30,600
	Installed capacity (MW)	18,380	20,330	21,530	22,110	23,030	26,690
	Average daily operation hours (hours)	1.62	1.25	1.36	1.64	1.88	3.13
Xilongchi	Annual power generation amount (GWh)	381	31	114	401	620	1,638
	Installed capacity (MW)	1,200	1,200	1,200	1,200	1,200	1,200
	Average daily operation hours (hours)	0.87	0.07	0.26	0.92	1.42	3.73

Source: Prepared by the evaluator using documents provided by JICA, the 13th Five Year Plan for the Electric Power Industry and the list of basic statistical data for the power sector in 2015

Since 2012, one year after project completion, the slowing down of the economic growth greatly reduced the growth of the power demand while the construction of many new power stations, primarily thermal power stations, was completed (including those with a high-power supply adjusting capacity). As a result, the power supply and demand situation in Shanxi Province greatly improved, restricting the role of Xilongchi Power Station to that of handling the peak demand which is the essential role of a pumped storage power station. The gap between the maximum load and minimum load was reduced, making a strong capacity to deal with the peak demand less necessary. As such, the utilization level of the Xilongchi Power Station was low in 2013, two years after project completion.[12] When compared to the target value based on approximately 4.1 operating hours (generating hours) a day, the actual operating hours of the Xilongchi Power Station for 2013 through 2015 were lower than the target.[13] Nevertheless, it is judged that this power station sufficiently fulfilled its role of handling the peak demand due to the facts that ① it maintained a reasonable level of the annual power generating amount when compared to the actual performance of

[12] If the Project had been completed in 2009 as planned, the year of 2011 which was two years after project completion would have been a year in which adjustment between the maximum load and minimum load was most required because of the tightest power supply and demand situation in Shanxi Province, surely achieving the target values. In view of this scenario, the delay of project completion greatly affected the achievement status of the effectiveness indicator for the Project. A person in charge of the power grid of Shanxi Province at the Shanxi International Electricity Group Limited Company (hereinafter referred to as "Shanxi Electricity Company") expressed the opinion that "it was highly regrettable that the Project had not been completed by 2010-2011 when the power supply and demand adjusting capacity was most needed.

[13] It must be fully noted for the present evaluation of the Project that a small power generation amount does not necessarily mean a low level of effectiveness of the Project as the actual power generation amount greatly fluctuates from one year to another in the case of pumped storage power generation. This statement is supported by the facts that ① the JICA Operation Indicator and Effect Indictor Reference in ODA Loan Projects (July, 2014) spells out that (in view of its characteristics) not reaching the targets for the operating hours (generating hours) and power generation amount does not always lead to a low evaluation in the case of pumped storage power generation, ② China's 13th Five Year Plan for the Electric Power Industry does not set a target power generation amount for pumped storage power generation and ③ in the power sales contract related to the Project, a fixed charge based on the installed capacity is agreed upon regardless of the actual power generation amount.

pumped storage power stations in China as shown in Table 8 and ② it was primarily used in winter when the power supply and demand tends to be tight in Shanxi Province.

Since 2015, China has achieved the development of environment-friendly alternative energies and Shanxi Province has witnessed a great increase of the amount of development as well as the power generating amount of wind and photovoltaic power generation. Because of the unstable nature of the power supply from these alternative energy sources, however, further enhancement of the adjusting capacity is required, prompting the active use of the Xilongchi Power Station and resulting in an increase of the operating hours (generating hours) and power generation amount. The role of the Project has changed again to emphasize its function of adjusting the power supply and demand with a view to facilitating the development of alternative energies in addition to its conventional function of dealing with the peak demand. This new trend is commonly observed with pumped storage power stations throughout China and their annual power generating amount notably leaped in 2016 as shown in Table 8. Given the current national policy of continually developing alternative energies along with the plan to construct new pumped storage power stations, the importance of the Project and its pumped storage power station will remain high. Because of such prospect, those in charge of the Project at the executing agency assert that the Xilongchi Power Station will be operated above the target level with its new role.

3.3.2 Qualitative Effects

The assumed qualitative effects at the time of appraisal were ①containment of the fuel consumption and ② improvement of the reliability and economy of power supply system operation due to the mitigation or reduction of DSS operation.

According to the results of the interview survey with Shanxi Electricity Company, the number of DSS operation has drastically fallen since 2012 and is now hardly put into practice except at special times such as Chinese New Year. A situation requiring DSS operation now seldom occurs (several times a year), illustrating a massive improvement in this regard. The reasons for such improvement include alleviation of the tight power supply and demand situation since 2012 and overall decreasing trend of the gap between the maximum load and minimum load as described earlier in addition to the increased adjusting capacity due to the completion of the Project. Even today when the environment of the power generating business has changed in that the power supply and demand gap is increasing due to an increasing power demand and the capacity to adjust the power supply and demand is increasing due to the expansion of power generation using alternative energy sources, DSS operation is no longer necessary, suggesting a major contribution by the Project.

Officials of Shanxi Electricity Company who were interviewed for this ex-post evaluation expressed their understanding that the reduction of inefficient operation of power plants and improvement of the thermal efficiency due to a stable output, both of which were the result of mitigated or reduced DSS operation, had achieved ① "a reduction of the fuel consumption". Regarding ② "improvement of the reliability (stability) and economy of power supply system operation", although no data indicating the voltage, frequency, etc. of the power grid to show the relevant situation was not obtained, their understanding was that mitigated or reduced DSS operation had contributed to the reduction of the power station operation and maintenance cost and prolongation of the service life of the generating equipment.[14]

Two further matters can be pointed out as described below.

Realization of a stable power supply, including the prevention of large-scale outages: A stable power supply is essential for Shanxi Province to achieve stable as well as sustained socioeconomic development. A wide range of stakeholders, including those responsible for the electric power policy of the provincial government of Shanxi, have expressed their understanding that both the level of contribution and the role played by the Project have been great (despite the small power generation amount) from the viewpoint of improving the reliability of power supply system operation, including the prevention of large-scale outages, against the background of a continual increase of the power demand.

Improvement of the adjustment of the power supply and demand in wider North China: Geographical widening of the power network management in China is being promoted to facilitate improvement of the stability and economy of the power supply system. Since 2016, the Xilongchi Power Station has been incorporated in not only the provisional power supply network of Shanxi but also in the North China power supply network, contributing to the improvement of the stability and economy of the power supply system through its involvement in the adjustment of the power supply and demand in a much wider area.

[14] Even in 2011 when the power supply and demand situation was very tight, there were neither any accidental nor planned outages. Because of this, no clear opinion of the achievements of the Project were expressed during the interview survey.

3.4 Impacts

For evaluation of the impacts, resetting of the target values and other changes were made as described later in consideration of the improved environmental measures and technological innovation in China.

3.4.1 Intended Impacts

The identified quantitative impact was "the air pollution prevention effect" while the identified qualitative impacts were "contribution to the socioeconomic development and poverty reduction in a local area" and "facilitation of the development of alternative energies in Shanxi Province".

(1) Air Pollution Prevention Effect

The impacts (quantitative indicators) assumed at the time of appraisal were ① annual reduction volume of coal combustion and ② reduction of the emission of air pollutants, etc. (NOx, SO_2, dust and CO_2). The target values for the air pollution prevention effect of the Project were calculated by the method explained in the box below.

Item	Calculation Method
Coal combustion/ reduction volume	• The case where the power station constructed under the Project (with-case) is compared to the case where an additional thermal power station is constructed instead of the planned power station under the Project (without-case) to calculate the reduction amount of coal combustion under the Project (reduction amount per one KWh of power generated under the Project). • For calculation of the reduction amount of coal combustion, the "coal consumption curve" which takes the scale of power generation and situation of use of provincial power generation into consideration and other information are used. • The operating hours (generating hours) of a pumped storage power station are assumed to be 5.5 hours a day (annual power generation amount of 2,409 GWh).
Reduction volume of air pollutants, etc.	• Based on the actual coal consumption and emission volume of air pollutants by thermal power generation in Shanxi Province, the emission volume of air pollutants, etc. per one ton of coal combustion is calculated to determine the target value for the Project.

At the time of appraisal, however, the assumed operating hours (generating hours) of 5.5 hours/day (annual power generation amount of 2,409 GWh) was used for calculating the coal combustion reduction volume, and the subsequently expected "coal combustion reduction volume" and "reduction volume of air pollutants, etc." were set as the target values of air pollution prevention effect of the Project. Meanwhile, the target values for the power generation amount set for the Project were based on the operating hours of approximately 4.1 hours and annual power generation amount of 1,796 GWh, creating discrepancies in the target values relating to the air pollution prevention effects. For the present ex-post evaluation, these "target values" were

revised as shown in Table 9.

Table 9: Target Values Relating to the Air Pollution Prevention Effect of the Project

	At Time of Appraisal (before revision: annual power generation amount 2,409 GWh)	At Time of Ex-Post Evaluation (after revision: annual power generation amount 1,796 GWh)
Annual reduction volume of coal combustion	259,000 tons	193,000 tons
Reduction volume of NO_X	3,000 tons	2,236 tons
Reduction volume of SO_2	6,100 tons	4,547 tons
Reduction volume of coal dust	2,700 tons	20,130,000 tons
Reduction volume of CO_2	700,000 tons	522,000 tons

Source: Prepared by the evaluator using documents provided by JICA

For estimation of the actual values, it was attempted to reset the calculation formula to reflect the current conditions because the degree of impact of power generation on the environment had changed as a result of improved environmental measures and technological innovation since the original appraisal. However, for "the reduction volume of coal combustion per GWh of power generation", the coal consumption curve, etc. calculated at the time of appraisal were used due to the lack of the latest versions of such information. In the case of "the reduction volume of air pollutants, etc. per ton of coal combustion reduction volume", it was decided to use the latest relevant performance in entire China as shown in such obtainable reference materials as "the 13th Five Year Plan for the Electric Power Industry" for calculation. The results are shown in Table 10. "The actual values" were then calculated using this set of two standards.[15]

Table 10: Air Pollution Prevention Effect per 1 GWh of Power Generation

	Standards at Time of Appraisal	Standards at Time of Ex-Post Evaluation
Saved amount of coal combustion	Approx.107.51 tons	Approx. 107.51 tons (no change)
Reduction volume of NO_X	Approx.1.25 tons	Approx.0.96 tons
Reduction volume of SO_2	Approx.2.53 tons	Approx.0.92 tons
Reduction volume of coal dust	Approx.1.12 tons	Approx.0.73 tons
Reduction volume of CO_2	Approx.290.58 tons	Approx.89 tons

Source: Prepared by the evaluator using documents provided by JICA, the 13th Five Year Plan for the Electric Power Industry and the list of basic statistical data for the power sector in 2015

Note: The principal reasons for the change of the air pollution prevention effect per GWh of power generated between the time of appraisal and the time of ex-post evaluation are ① the progressive introduction of power generating facilities producing less environmental load and ② the promotion of environmental measures at existing power stations.

[15] When the emission reduction volume of air pollutants, etc. (per ton of coal combustion reduction volume) was calculated at the time of appraisal, data for entire Shanxi Province was used. For recalculation this time, data for entire china was used as data for Shanxi Province was unavailable.

Accordingly, the situation of air pollution prevention effect of the Project can be summarized as shown in Table 11.

Table 11: Situation of Air Pollution Prevention Effect of the Project

		Revised Target	Actual						
		(2011)	2011	2012	2013	2014	2015	2016	2016
		2 years after project completion	Year of project completion	1 year after project completion	2 years after project completion	3 years after project completion	4 years after project completion	5 years after project completion	Target achievement ratio
	Annual electric power sold (GWh)	1,796	381	31	114	401	620	1,638	91%
Standards at the time of appraisal	Annual reduction volume of coal combustion (,000 tons)	193	41	3	12	43	67	176	91%
	Reduction volume of NO_X (tons)	2,236	474	39	142	499	772	2,040	91%
	Reduction volume of SO_2 (tons)	4,547	965	78	289	1,015	1,570	4,147	91%
	Reduction volume of coal dust (tons)	2,013	427	35	128	449	695	1,836	91%
	Reduction volume of CO_2 ('000 tons)	522	111	9	33	117	180	476	91%
Standards at the time of ex-post evaluation	Annual reduction volume of coal combustion (,000 tons)	193	41	3	12	43	67	176	91%
	Reduction volume of NO_X (tons)	2,236	364	30	109	384	593	1,566	70%
	Reduction volume of SO_2 (tons)	4,547	351	29	105	369	571	1,508	33%
	Reduction volume of coal dust (tons)	2,013	278	23	83	293	453	1,196	59%
	Reduction volume of CO_2 ('000 tons)	522	34	3	10	36	55	146	28%

Source: Prepared by the evaluator using documents provided by JICA and responses to the questionnaire of the executing agency.

The standards at the time of appraisal basically linked the state of any achievement of each indicator related to the air pollution prevention effect to the power generation amount of the Xilongchi Power Station. Therefore, for the year of 2013 which was two years after project completion and the target values were set at the time of appraisal, all of the indicators failed to achieve their targets because the target value for the power generation amount was not achieved (target achievement ratio of 6%). In subsequent years, the power generation amount increased each year, nearly reaching the target level in 2016. Accordingly, each indicator related to the air pollution prevention effect also reached the 91% level of the original target. However, when the actual average annual performance for the period of four years from 2013 to 2016 is compared to the original target, the actual achievement ratio is as low as 39%.[16]

[16] As described later, the Project is believed to have the effect of facilitating the development of alternative energy sources (even though quantitative evaluation of this effect cannot be done) and, therefore, the air pollution prevention effect of the Project should be better than this figure.

When the standards reflecting the improvement of environmental measures and technological innovation after appraisal are used to evaluate the air pollution prevention effect of the Project, the general trend is similar to that with the standards adopted at the time of appraisal. However, the actual air pollution prevention effect has been much lower. Even in 2016 when the power generation amount almost reached its original target, some indicators greatly undershot their respective targets. The level of achievement was quite low at around 30% for the reduction of SO_2 and CO_2 for which measures to reduce these emissions had made great progress.[17]

(2) Contribution to Local Socioeconomic Development and Improvement of Local Poverty

The Project made a certain contribution to the increase of the fiscal revenue of the county government. Shanxi Xilongchi Pumped Storage Power Station Co., Ltd. (hereinafter referred to as "Xilongchi Power Company") was the third highest tax payer in Wutai County in 2015/2016 and the amount of its paid tax exceeded 5% of the county's revenue. Against the background of sluggish tax revenue under the recent low economic growth, the tax revenue from Xilongchi Power Company was highly significant for a state-designated poor county like Wutai (against the planned revenue of Wutai County of 65.31 million yuan in 2011 at the time of appraisal, the actual revenue was 317.34 million yuan in 2010 and 711.72 million yuan in 2015, showing much greater revenue than planned). In this county, the improvement of social infrastructure and services has been in progress using the increased fiscal revenue, including tax revenue from project-related business operations. While the actual monetary amount and other details are unknown, the construction work under the Project produced employment for construction workers, those providing accommodation for project-related personnel and food and beverage services in areas around the project site. At the time of the ex-post evaluation, many trucks were seen transporting coal using the road constructed for the Project. Accordingly, it is reasonable to assume that the Project had made a certain contribution to the development of the local socioeconomy.

Although Wutai County is still a state-designated poor county, the number of poor people has declined (currently some 7,000 - 8,000) and the county aims at eliminating all poor people by 2020. The increased fiscal revenue has made it possible for the county to strengthen such measures designed to reduce poverty as the fostering of and assistance for side businesses and infrastructure development. The interview survey

[17] It must be fully noted that the improvement of environmental measures and technological innovation after appraisal are considered to be external conditions from the viewpoint of project management.

with county officials confirmed that the tax revenue from project-related business operations contributes to the implementation of poverty reduction measures to a certain extent.[18]

(3) Promotion of the Development of Alternative Energies in Shanxi Province

As mentioned earlier, both the Government of China and Shanxi Provincial Government stress and promote the development of alternative energies from the viewpoint of environmental protection (while no alternative energy sources existed in the province in 2012, the installed wind power and photovoltaic power generation capacities stood at 7,300 MW and 2,700 MW respectively in 2016 (hydropower generation 2,300MW). Power supply from alternative energy sources (wind power, photovoltaic power, etc.) is rather unstable, making it difficult to generate power in response to the power demand. Moreover, the hours of high level power generation by these alternative energy sources do not necessarily coincide with the hours of a high power demand. As such, there is always the possibility of wasting the generated electric power when the power generation exceeds the demand. This means that an increase of the power supply and demand adjusting capacity is essential for an increase of the installed capacity of alternative energy sources. Here is one reason for the growing expectation of the role to be played by pumped storage power stations. Accordingly, officials of State Grid Xinyuan Company[19] and Shanxi Electricity Company interviewed for the ex-post evaluation believe that it is possible to utilize the surplus electric power generated by wind power (portion exceeding the demand) without waste by means of using this portion of generated electric power for pumping operation (conversion of 1.25 KWh of electric power generated by wind power to 1 KWh of pumped storage power generation). It is assumed that some 70% of the installed capacity of pumped storage power stations will be used for adjustment of the power supply and demand in connection with the development of alternative energy sources. Shanxi Province has an installed ordinary hydroelectric power generation capacity of some 1,100 MW. The large seasonal fluctuation of the discharge of rivers used for power generation, however, means that ordinary hydroelectric power generation cannot be expected to perform a sufficient adjustment function, raising high expectations that the Xilongchi Power Station will perform this function. The rapid growth of the amount of power generated by the Xilongchi Power Station in recent years is believed to reflect such situation, illustrating the strong contribution of the

[18] Partly because of the commitment of the central government to promoting the development of social infrastructure in rural areas, the communication, road and power supply networks fully cover even poor areas.

[19] This company manages and supervises all pumped storage power stations in China.

Project to facilitation of the development of alternative energies (and air pollution prevention through such development) in Shanxi Province.

3.4.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

The Environmental Bureau of the county government conducted monitoring of the natural environment in association with the implementation of the Project in addition to its ordinary environmental monitoring for a period of three years during which the impacts on the natural environment were thought to be great, if any, on three items, i.e. air quality, noise and dust. The interview survey with officials of the county's Environmental Bureau found that all of the monitoring results for these three items were within the respective standards, posing no significant problems. There were cases where a minor problem involving dust, etc. occurred during the construction period but appropriate measures were implemented through consultations with the contractors. In regard to the river water quality, the ordinary monitoring regime (checking of the state of water pollution in the downstream of the river four items a year) which is still implemented at the time of ex-post evaluation checks the water quality and no deterioration of the water quality has been found.[20] At the time of project planning, human sewage from the power station complex was thought to pose the biggest problem. However, sewage treated on site to meet the relevant standards is mostly used for greening of the site, etc. As such, hardly any treated sewage is currently discharged to the river. Accordingly, it is safe to judge that the Project has caused hardly any negative impacts on the natural environment.

(2) Resettlement and Land Acquisition

The actual situation of resettlement and land acquisition necessitated by the implementation of the Project is summarized in Table 12 and the actual figure exceeds the planned figure for both resettlement and land acquisition. The actual number of resettled residents represents the revised figure based on the results of the survey on the intentions of residents which was conducted again at the implementation stage. The increase of the scale of land acquisition was, in fact, the acquisition of waste land (the size of housing plots and farmland to be acquired remained the same as planned) to fulfill the operational needs of the power station. As such, no special problems are observed in regard to these matters.

[20] Water required for pumping operation is taken from the river but the actual intake volume is limited to replenishing the amount of water lost due to evaporation, etc. from the two regulating reservoirs, causing hardly any impact on the river flow.

Table 12: Implementation Situation of Resettlement and Land Acquisition

Item	Target Area	Planned	Actual
Land acquisition	Xihe Village (administrative village) and Xilongchi Village (natural village)	240 ha (of which 7.5 ha is housing plots and 92 ha is farmland)	330 ha (of which 7.5 ha is housing plots and 92 ha is farmland)
Resettlement	Construction site for the upper regulating reservoir (Xilongchi Village (natural village))	630 persons	55 persons (Done in 2003) On the basis of the resident survey results, 44 persons were moved to homes of relatives or friends, including those outside the village, and 11 persons were individually moved to other areas.
	Construction site for the lower regulating reservoir (Xihe Village (administrative village))		620 persons (Done in June, 2003) Collectively moved to a site near the center of the village

Source: Documents provided by JICA and responses to the questionnaire of the executing agency

Residents of Xihe Village (construction site of the lower regulating reservoir) were collectively resettled at a former agricultural experiment station site.[21] In accordance with the national standards, the amount of the compensation for each household was decided taking the conditions of the cultivated land, crops cultivated and farming income into consideration (the farming area per person was increased from 0.5 mu (shimu)[22] to 1 mu). In addition, 600 yuan is offered every year for 20 years from 2003. A visit to the resettled area and interview results with officials and residents of Xihe Village confirmed that the income and standard of living of these resettled residents have clearly improved. While some residents purchased a house (floor area of 90 m^2 at a price of 40,000 yuan) using the financial compensation, etc., those residents which could not afford the price immediately were given the facility of installment payments. Therefore, the residents did not experience any financial problems following their resettlement. Because the resettled site enjoy a good location being near to the center of the town, business opportunities other than farming (and the income from them) have increased (the annual income per capita has doubled from 3,000 yuan to 6,000 yuan and approximately two-thirds of this income comes from businesses other than farming). While the previous residential site did not have a full range of social infrastructure, the new site has such lifelines as water supply, sewerage and gas supply which have greatly contributed to the improved standard of living. The village authority has constructed apartment blocks on vacant land. The resulting favorable living environment has attracted purchasers from outside the village, increasing the village population to as many as 1,100 at present. The conversion of farming from dry

[21] The acquisition of the resettlement site did not pose any problems.
[22] Mu (shimu) is a Chinese unit for agricultural land and is equivalent to approximately 666 m^2.

field farming to rice cultivation planned at the time of appraisal has been implemented as planned with the guidance of nearby farming households with experience of rice cultivation and the county's Agricultural Bureau. As a result, the newly settled farming households have been capable of cultivating rice without assistance since the second year. However, the rice acreage is showing a declining trend because although rice cultivation produces a slightly higher income per unit of land than maize cultivation, it requires much greater care than the latter (at the time of ex-post evaluation, rice and maize are cultivated on some 20% and 70% respectively of the arable land). The resettlement of the residents of Xihe Village is recognized as a successful example of a resettlement project and the new site accepts study visits from those involved in similar projects.

In the case of Xilongchi Village (the construction site of the upper regulating reservoir), 44 people were moved to the home of relatives or friends, including those outside the village, while 11 people were individually moved to other areas, following the results of the survey on the intentions of residents. As in the case of Xihe Village, compensation was provided based on the national standards but the amount of financial compensation was slightly higher than the level paid to the residents of Xihe Village in view of individual resettlement rather than collective resettlement. The interview survey with resettled villagers of Xilongchi Village found that the living conditions, etc. of those moving to other areas had improved compared to the poor conditions experienced at the previous village site located in a mountain area. A high level of satisfaction was confirmed particularly in regard to improvement of the educational environment and conditions for children. The situation of those who resettled within the same village area is unclear as an interview survey with these people could not be conducted. However, it is reasonable to assume that the standard of living has improved to a certain extent because of ① the assistance provided by Xilongchi Power Company in the form of dug wells and assistance for farmland improvement in areas near the power station and ② much improvement of access to outside the village due to the improvement of roads linking the power station and other areas under the Project.

According to the interview survey results with the county government, the factor for the successful resettlement of residents was the well-thought out advance preparations by the county government, including the establishment of a resettlement office dedicated to the Project and served by 14 staff members. The deputy governor of the county played a leading role, including on-site coordination, and a survey on the intentions of residents and explanatory meetings were actively organized. Although the office dedicated to the Project has already been closed, the county government's Immigration Office provides such follow-up services for resettled residents as

consultations on daily life and consumer affairs.

Housing for resettled villagers
(Xilongchi Village)

Rice cultivation at the resettled site
(Xilongchi Village)

(3) Development of Other Pumped Storage Power Stations in China and Facilitation of Business Orders Placed to Japanese Companies

The interview survey with officials of State Grid Xinyuan Company which manages pumped storage power stations in China found that the Project is considered a successful model for pumped storage power stations partly because of its employment of advanced technologies. Following the success of the Project, Shanxi Province plans to promote the construction of further pumped storage power stations. The utilization of state-of-the-art technologies at the Xilongchi (Pumped Storage) Power Station has been attracting many visitors involved in hydropower generation in China. As such, the Project has had a certain impact on the development of pumped storage hydropower generation in other parts of China.

For the construction of the Xilongchi Power Station, Japanese companies delivered a number of main equipment, including generators and pump turbines. Those Japanese manufacturers involved in the Project subsequently succeeded in winning orders mainly through their local subsidiaries for equipment, etc. (four sets of 320,000 kW pump turbines, generators and accessories) for the Qingyuan Pumped Storage Power Station (Guangdong Province) in April, 2010. The underlying reasons for this success were ① the Chinese stakeholders in pumped storage hydropower generator were greatly impressed by the excellent equipment produced by Japanese manufacturers (including the aspects of noise, vibration, etc.) and ② Xilongchi became an actual showpiece of Japan's successful contract to build a pumped storage power station in China.[23] The Qingyuan Power Station was the first order for a pumped storage power

[23] It was possible for Japanese companies with both advanced technical capability and competitiveness over other companies to win the contract for the Project because of the facts that " the Project would involve a

station successfully won by Japanese manufacturers involved in the Project in a domestic tender in China.[24] The staff members of these Japanese manufacturers interviewed for the ex-post evaluation said that the receipt of an order for the Project undoubtedly contributed to new orders and that they are planning to continue to compete for orders as pumped storage power generation is one of the few fields in which Japanese companies enjoy better competitiveness over Chinese companies.[25] Accordingly, the Project is believed to have contributed to facilitate the winning of orders for pumped storage power generation projects in China by Japanese companies.

As far as the quantitative effects relating to the effectiveness and impacts of the Project are concerned, the Xilongchi Power Station performs the roles of "handling the peak demand" and "adjusting the power supply and demand for the development of alternative energies (promotion of air pollution prevention)" in line with the changing roles expected of the Project. At the time of ex-post evaluation, the target values for various indicators are mostly achieved. The expected qualitative effects (① reduction of fuel consumption and ② improved reliability and economy of power system operation through the mitigation or reduction of DSS operation) are also achieved. Other positive impacts include its contribution to the socioeconomic development and poverty reduction of local communities, development of pumped storage hydropower generation in other areas of China and facilitation of the winning of orders by Japanese companies. No significant problems are observed in such aspects as impact on the natural environment, resettlement of residents and land acquisition. However, all the indicators relating to the effectiveness and impacts considerably undershot their respective target values for two years after project completion set at the time of appraisal.

This Project has achieved its objectives to some extent. Therefore, the effectiveness and impact of the Project are fair.

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large head which was unprecedented in China" and that "the ODA loan project (international competitive bidding) meant that Japanese companies were able to bid without the obligation of technology transfer".

[24] One important factor for the successful bid was the China's shifting of the emphasis when deciding the contractor for a pumped storage power generation project in China on "technology transfer" to "a domestic company (private tender)" and further to "a domestic company in general (including a foreign subsidiary)".

[25] The 13th Five Year Plan for the Electric Power Industry plans to commence the construction of pumped storage power stations with a total installed capacity of 60 million kW throughout China in the five year period up to 2020.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

As a result of the Chinese government policy of placing all pumped storage power stations in the country under the control of State Grid Xinyuan Company (established in March, 2005 under State Grid Corporation of China) for the purpose of the expert as well as central management of these power stations, the superior organization and shareholder composition of Xilongchi Power Company has changed as shown in Table 13. At the time of appraisal, it was planned that Shanxi Electricity Company would be responsible for the operation and maintenance of the power station and Xilongchi Power Company would be responsible for managing its assets. Following the change of the systems, State Grid Xinyuan Company and Xilongchi Power Company are currently responsible for the management of assets and the operation and maintenance of the power station respectively. Despite such partial changes of the systems due to the Chinese government policy, etc., no problems have consequently emerged as these changes apply to all pumped storage power stations in China. The shareholder ratio of local organizations of Shanxi Province has dropped compared to the original plan but power generation operation is conducted under the instruction of Shanxi Electricity Company as originally planned from the viewpoint of the central operation of the power system.

Table 13: Shareholders and Operation and Maintenance System of Xilongchi Power Company

	At Time of Appraisal		At Time of Ex-Post Evaluation	
Shareholders	Shanxi Electricity Company Shanxi Local Electric Power Group Company	73% 27%	State Grid Xinyuan Company China International Energy Group State Grid Jibei Electric Power Company State Grid Shanxi Electric Power Company Shanxi Electricity Company	43% 17% 16% 14% 10%
System	Supervising agency	State Electric Power Company	Supervising agency	State Grid Xinyuan Company
	Operation and maintenance	Shanxi Electricity Company	Operation and maintenance	Xilongchi Power Company
	Asset management	Xilongchi Power Company	Asset management	State Grid Xinyuan Company
	Instruction of power generation	Shanxi Electricity Company	Instruction of power generation	Shanxi Electricity Company

Source: Documents provided by JICA and responses to the questionnaire of the executing agency

As of March 2017, Xilongchi Power Company employs 79 persons (of which 51 are engineers). According to the results of interviews with officials of this company, the current staff strength is satisfactory and there are no personnel-related problems.

3.5.2 Technical Aspects of Operation and Maintenance

The basic common system for the operation and maintenance of pumped storage power stations nationwide in accordance with the policy of State Grid Xinyuan Company is to entrust much of the equipment maintenance (mainly routine work) to an external specialist company[26] and for in-house engineers of the power station (employees of Xilongchi Power Company in the present case) to conduct work requiring high level technical skills and to supervise the entrusted external company. One reason for such an arrangement is that the upper limit of employees is set forth by State Grid Xinyuan Company.

Many engineers of Xilongchi Power Company are officially qualified advanced engineers or engineers who, therefore, have a sufficient technical capability and experience. Staff members of Xilongchi Power Company undergo not only common training designated by State Grid Xinyuan Company for those working at pumped storage power stations nationwide but also the company's own training which is planned by the specialized section and periodically as well as methodically conducted. External companies to which maintenance, etc. is entrusted are periodically selected by the tender process. These companies must have sufficient experience of the work at pumped storage power stations throughout China based on common nationwide criteria. Maintenance work is conducted on the basis of uniform standards which are applicable to all pumped storage power stations in China. As a result, both Xilongchi Power Company and the external company entrusted with the maintenance work of the Xilongchi Power Station have the necessary operational and maintenance skills. As the maintenance of equipment and handling of problems have been properly conducted, no serious problems have occurred since the commissioning of the power station. The system in place to deal with a major operational or maintenance problem is that such a problem is dealt with by the assistance of the equipment manufacturer(s) and State Grid Xinyuan Company. If necessary, the assistance of another pumped storage power station is sought. When the No. 4 unit of the Xilongchi Power Station malfunctioned in 2011, a swift response was made with the assistance of the manufacturer with operation restarting within one month.

[26] Each work is graded as one of four grades (A through D) based on the required technical level. Grade B work through Grade D work requiring a relatively low level of technical skills, etc. are externally entrusted (Grade A work: total overhaul, inspection and repair of equipment; Grade B work: solving of problems which cannot be eliminated by Grade C work; Grade C work: standard inspection and repair of damaged or deteriorated equipment; Grade D work: handling of minor problems of equipment which is mainly running smoothly).

3.5.3 Financial Aspects of Operation and Maintenance

As mentioned earlier, Xilongchi Power Company conducts power generating operation under the instruction of Shanxi Electricity Company which operates the power system. The entire amount of generated electricity is purchased by the latter. These two companies have concluded a contract by which a fixed amount based on the installed capacity is paid by the latter to the former irrespective of the generated amount of power as planned at the time of appraisal. Since 2012 when all four generating units became operational, Xilongchi Power Company has received some 450 million yuan or more annually. As a result, its annual account has been in surplus and its financial status has been stable even though the actual revenue changes from one year to another.

The financial performance of Xilongchi Power Company is shown in Table 14. As already described in the section on the FIRR (see 3.2.3), the size of the revenue is around half of the planned revenue at the time of appraisal. Because of this, the profitability is lower than planned. However, the financial status of the company is stable at present. Unlike the plan prepared at the time of appraisal (the power purchase contract is to be revised every three years), the contract is now due for revision every year. However, as this revision follows an appropriate procedure based on regulations set by the Government of China and also as the contracted amount has remained unchanged, no financial problem has so far occurred. The provincial government and other stakeholder organizations intend to continue their support so that Xilongchi Power Company can conduct its business in a stable manner.[27]

Table 14: Historical Financial Performance of Xilongchi Power Company

(Unit: million yuan)

	2010	2011	2012	2013	2014	2015	2016
Revenue	227.2	311.6	455.3	454.9	454.5	455.3	454.2
Expenditure	292.7	338.9	302.7	147.8	315.5	450.9	409.9
Profit	-65.5	-27.3	152.7	307.1	139.0	4.4	44.3

Source: Responses to the questionnaire of the executing agency

3.5.4 Current Status of Operation and Maintenance

The monitoring, maintenance and periodic inspection of equipment at the Xilongchi Power Station are properly conducted by the external company entrusted with this work. The operation of this power station is monitored on-line for 24 hours a day by

[27] The balance sheet of Xilongchi Power Company for the 2016 business year shows 3,410 million yuan of assets (3,310 million yuan of fixed assets and 1,000 million yuan of current assets), 2,040 million yuan of liabilities (1,490 million yuan of fixed liabilities and 550 million yuan of current liabilities) and 1,360 million yuan of capital, posing no problems.

State Grid Xinyuan Company and no serious problem has occurred since its commissioning to the time of the ex-post evaluation. There have been no problems in regard to the procurement of spare parts. The field reconnaissance conducted as part of the ex-post evaluation has confirmed that ① each equipment is tidily as well as cleanly maintained and ② guidance and awareness raising for in-house engineers as well as for workers of the entrusted company are actively conducted using instruction posters, etc. designed to ensure smooth operation and maintenance. Measures and cautionary notices to ensure safety are specially emphasized. According to officials of the executing agency, the handling of any equipment breakdown or abnormality is smoothly conducted in cooperation with the entrusted company. As such, the conditions of the main facilities and equipment are generally good. It is safe to assume that the operation and maintenance of the Xilongchi Power Station are properly conducted based on the relevant national rules for pumped storage power stations and those of Xilongchi Power Company.

While the operating rate of the Xilongchi Power Station was low for several years after project completion as described earlier it has been increasing in recent years in response to the growing need for the power supply and demand adjustment function of this power station following the development of alternative energy sources.

No major problems have been observed in the institutional, technical and financial aspects and current status of the operation and maintenance system. Therefore, the sustainability of the Project effects is high.

4. Conclusions, Lessons Learned and Recommendations

4.1 Conclusions

The objective of the Project was to improve the peak demand handling capability and the reliability as well as economy of power system operation by constructing a pumped storage power station in Shanxi Province, thereby contributing to the containment of the emission volume of air pollutants. The Project was in line with the electric power and environmental policies of the Government of China as well as the government of the target province, development needs of China to improve air pollution and to increase the stability and economy of power supply and Japan's ODA policy. As such, the relevance of the Project is high. The efficiency of the Project is fair because of the fact that although the project cost was within the planned cost, the project period exceeded the plan. The expected role of the Project (Xilongchi Power Station) has changed as a result of the changing circumstances of the electric power industry in Shanxi Province. In response to such changes, the Xilongchi Power Station currently performs its principal roles of

“responding to the peak demand” and “adjusting the power demand and supply for the development of alternative energies (facilitation of air pollution prevention) without fail and various indicators had mostly achieved the target values by the time of this ex-post evaluation. Sufficient positive effects are observed with the anticipated improvement of the stability and economy of power supply. A certain effect of the Project is also confirmed in relation to ① development of the socioeconomy and improvement of poverty in local communities and ② facilitation of the further introduction of Japanese technologies to China. In contrast, the target values set at the time of appraisal were substantially undershot for all indicators of the effectiveness and impacts two years after project completion. In consideration of the foregoing, the effectiveness and impact of the Project are fair. The sustainability of the Project poses no problems in terms of the institutional, technical and financial aspects. As good operation and maintenance conditions were confirmed for the facilities and equipment, the sustainability of the Project is high.

In light of the above, the Project is evaluated as satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

None

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

None

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
1.Project Outputs	1) Upper regulating reservoir: 4.2 millionm^3 2) Lower regulating reservoir: 4.2 millionm^3 3) Underground power station: 300MW x 4 units 4) Headrace and tailrace 5) Switchgear: transformers 340MVA × 4, 500kV outgoing system 6) Consulting service: Assistance for tender; review of the detailed design; assistance for work supervision 7) Procured equipment: Reversible pump-turbine, GIS, cables, auxiliary equipment, etc.	1) Upper regulating reservoir: 4.6 millionm^3 2) Lower regulating reservoir: 4.8 millionm^3 3) As planned 4) As planned 5) As planned 6) As planned 7) Quantities, etc. of monitoring equipment, etc. were slightly changed due to necessary circumstances.
2. Project Period	November, 2001 – August, 2009 (94 months)	November, 2001 – August, 2011 (118 months)
3. Project Cost Amount Paid in Foreign Currency Amount Paid in Local Currency Total ODA Loan Portion Exchange Rate	23,241 million yen 54,750 million yen (3,650 million yuan) 77,991 million yen 23,241 million yen 1yuan =15 yen (As of September, 2001)	19,069 million yen 50,140 million yen (3,581 million yuan) 69,209 million yen 19,069 million yen 1yuan =14.0 yen (Average between 2001 and 2011)
4. Final Disbursement	October, 2015	